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APOLLO MONTHLY PROGRESS REPORT

NAS9-150

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85

30 November 1962

CLASSIFICATION CHANGE

To UNCLASSIFIED
By authority of GDS - EO 11652 Date 12/31/72
Changed by L. Shirley
Classified Document Master Control Station, NASA
Scientific and Technical Information Facility

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NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION

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FORM M158-D-4 LEDGER REV. 2-61

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ILLUSTRATIONS

TABLES

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PROGRAM MANAGEMENT

SUMMARY

A program review of the following major tasks was undertaken during the report period:

1. Environmental design criteria
2. Reorientation of qualification testing
3. Revision of GSE concept to incorporate spacecraft prelaunch automatic checkout equipment (SPACE)
4. Reduction of documentation requirements

Environmental design criteria, redundancy, alternate operational modes, spares provisioning, and crew safety/reliability probabilities have been reviewed. Limits for operating conditions have been redefined.

With an aim toward cost reduction, qualification testing criteria have been reoriented to provide a qualification program that uses selective test evaluation at a practical assembly level, with minimum testing by subcontractors. The test program is based more on engineering rationale and less on statistical rigor.

GSE requirements will be established for the integrated systems requirements; in addition, maximum use of available government-furnished property (GFP) is to be investigated to reduce cost. The SPACE consoles at S&ID and AMR for prelaunch reliability checkout will incorporate quantity, quality, trend, and time factors to reinforce all phases of GSE requirements and interfaces.

Review of documentation requirements has resulted in deletion of redundant reporting and assimilation of related material into the same volume, for both subcontractor and prime contractor reports.

PERT

S&ID PERT transition from 7090 to 1410 computer programming is essentially complete.

[redacted]

Preliminary blueline work copies of all General Order PERT Networks were transmitted to MSC with the exceptions of G.O. 7122 and G.O. 7157. IBM card decks for the following networks were also sent:

G.O.	Title
7125	Training and trainers
7126	Downey test operations
7134	Earth landing system

The following networks have been tentatively accepted by NASA-MSC:

7125	Training and trainers
7126	Downey test operations
7127	AMR test operations
7156	Tullahoma test operations

PROGRAM SCHEDULES

There were no changes in master program schedules during the month of November. Subcontractor schedule commitments were reviewed to ascertain that S&ID manufacturing schedules are adequately supported.

A joint NASA-S&ID meeting to take place during the next report period was requested by S&ID. This meeting is to review the Apollo logistics support program. Confirmation by NASA has not been received.

PLANS

Reading copies of the revised program plan were reviewed with NASA-MSC personnel at Houston on 16 November. The comments obtained from this review and from internal S&ID reviews were used as the basis for the finished revision. The document was ready for printing at the close of the report period and is scheduled for submittal to the Apollo System Project Office (ASPO) on 3 December.

LABORATORY EQUIPMENT AND FACILITIES

Major laboratory roadblocks continued to be equipment and facilities. Every effort is being made to continue laboratory development programs

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with the existing USAF special test equipment. This equipment is not adequate to meet the test criteria nor is it available in sufficient quantities. Industrial engineering and contracts personnel have been endeavoring to resolve these problems with NASA. To date they have been unsuccessful.

During this report period, the laboratory has been conducting tests on structural components, propulsion system components, instrumentation circuitry, display circuitry, and investigating material and processes in support of the Apollo design functions.

ASSOCIATE CONTRACTOR ADMINISTRATION

MIT

S&ID and MIT have designed an efficient configuration for the navigation and guidance system displays and controls. Interface control drawing (ICD) format has been agreed upon by NASA, MIT and S&ID. A tentative list of ICD's and several preliminary ICD's have been submitted to NASA and MIT for consideration. Progress in navigation and guidance GSE is still slow due to the SPACE concept and the attendant need for further clarification by NASA.

Convair

S&ID provided Convair with a master tool for controlling the Little Joe II/spacecraft adapter interface. In a review of the Little Joe II booster work, S&ID found no major problems; the Convair and S&ID effort is proceeding in an effective manner.

Grumman

Following announcement of the lunar excursion module contractor selection, S&ID briefed various NASA offices on S&ID proposed plans for technical and management coordination with Grumman and MSC.

SUBCONTRACT STATUS

The completion of the October 30 cost proposal indicated the need for additional cost reduction. During the report period, new concepts covering the criteria for documentation, qualification-reliability testing, design criteria, and GSE (including checkout equipment) were developed. These criteria are to be implemented by subcontractors and the schedule for completion of definitive negotiations has been revised as follows:

[redacted]

Subcontractor	Prior Target Date	Current Target Date
Aerojet-General	December 1962	1 February 1963
AiResearch	December 1962	15 February 1963
Avco	December 1962	5 January 1963
Beech Aircraft	December 1962	1 February 1963
Collins Radio	December 1962	19 February 1963
Eagle-Picher	December 1962	10 February 1963
Lockheed	December 1962	29 December 1962
Marquardt	December 1962	22 January 1963
Minneapolis-Honeywell	December 1962	28 February 1963
Northrop-Ventura	December 1962	21 February 1963
Pratt & Whitney	December 1962	18 January 1963
Thiokol Chemical	November 1962	29 December 1962
Westinghouse	January 1963	17 January 1963

NEW PROCUREMENTS

An order for the static inverters was placed with Westinghouse Corporation during the report period.

Orders are in process for the following items, and it is anticipated that the orders will be placed on the target dates shown below.

Item	Target Date
Positive expulsion tanks	15 December 1962
Main propellant tanks	31 December 1962
Battery charger	1 December 1962

Item	Target Date
Mission simulator	1 March 1963
Propellant utilization system	28 December 1962
Central timing system	31 December 1962
Radome	4 January 1963
2 KMC antenna	4 January 1963
Beacon antenna	4 January 1963
In-flight test system	15 January 1963
Recovery antenna	12 December 1962

CONTRACT CHANGE AUTHORIZATION (CCA) STATUS

CCA 1 - Change in Cabin Atmosphere

This change was included in the definitive contract proposal.

CCA 2 - Lunar Excursion Module Integration

S&ID has received NASA approval to delay pricing this CCA until a more adequate evaluation can be made or until further instructions are given.

CCA 3 - Added Requirement for Breadboard Fuel Cell Module

This requirement has been deleted by revision change to CCA 3.

CCA 4 - Command Module Lunar Excursion Module Docking Study

On 1 November 1962, a firm cost proposal in the amount of $111,734 was forwarded contracts to NASA. The proposal revised the schedule dates for submittal of this study from the terms of the CCA.

CCA 5 - Support Manuals Delivery Dates

The delivery dates of the proposal are in slight variance with the dates of the CCA. However, the variance appears to have little or no effect upon costs and no contract change proposal (CCP) action is contemplated.

CCA 7 - Changes in Propellant Systems

A preliminary CCP was submitted to NASA. A budgetary and planning price of $23, 000 was given and NASA was advised of possible schedule slippage resulting from this change.

CCA 9 - Deletion of Instrumentation Test Console from GSE

The contract change board (CCB) engineering representative indicates the GSE deleted by this CCA has been listed in the 30 October cost proposal as GFP.

CCA 12 - Deletion of Inserts and Adapters from Little Joe II Vehicles

This change has been introduced to the CCB and a preliminary evaluation has been made.

SPACECRAFT INTEGRATION

APOLLO CHECKOUT AND GSE CONCEPT

The general concept described encompasses the entire checkout program of an Apollo spacecraft and spacecraft systems from early boiler-plate to final configuration. The checkout program uses three major facilities as well as additional supporting areas. The operations conducted are summarized below in order of progressive stages of checkout:

Subcontractor Area

System and subsystem level testing for verification, certification, and prime-contractor acceptance will be accomplished at each respective sub-contractor facility. These tests will be supported by bench maintenance equipment, designed and built by the subcontractor, with full capability to detect and isolate malfunctions to the replaceable serialized unit and to exercise the systems within the boundaries of a test specification prepared by the subcontractor and approved by the prime contractor.

Prime Contractor (Downey Area)

Manufacturing will be responsible for the assembly, inspection, certification, and checkout of both the command and service modules and their associated systems prior to removal to the test preparation area. Combined system test units (CSTU) built by the prime contractor will be used in support of the manufacturing area as well as the combined systems and integrated system testing areas. The CSTU's will complement both bench maintenance equipment and SPACE. Flexibility of design will allow use of these units in calibration and alignment as well as detection and isolation of malfunctions.

The S&ID test preparation area will be the site of combined systems tests, vehicle integration, and integrated systems tests. Spacecraft and Spacecraft GSE integration and verification and all R&D operations will be carried out in this area. CSTU's common in design to those used in the manufacturing area will be employed to support local manual tests for necessary adjustments and calibration. Fault isolation will be carried out to the replaceable element level.

[redacted]

The CSTU's, as used for combined systems tests, will satisfy the major requirements of the SPACE concept. SPACE testing operations will be carried out at both Downey and AMR to supply system status, diagnostic checkout, and in-flight test system diagnostic information. These categories of information will be delivered via the data link in PCM format and telemetry system data for evaluation in the control room area.

Test operations will be conducted in three basic modes: local/manual, remote/manual, and remote/automatic. The first mode will be supported by CSTU's; the latter two by SPACE. Each testing phase will be preceded by local/manual operations which will accomplish the test set-up, calibration, alignment, and R & D engineering change evaluation as required. SPACE will then be used for the checkout test operations.

SPACE includes built-in, carry-on, and ground equipment. The first two classifications will be deployed within the spacecraft to accept all PCM command information for system control and stimulation. They will process all response information into a PCM format compatible with the ground equipment.

<u>AMR Area</u>

To accommodate shipping operations, the spacecraft will be demated at Downey. Additional combined system testing will be conducted after its arrival at AMR. The objective of these tests will be the same as of those conducted at Downey, but AMR will conduct additional testing neither possible nor required at the Downey facilities. CSTU's will support the initial set-up, calibration, alignment, etc., requiring local/manual mode of operation, and SPACE will be used for all possible testing phases in both the combined and integrated systems configurations.

Certification and customer acceptance will be accomplished by combined systems testing. Integrated systems testing will support all subsequent operations up to final removal of the carry-on equipment, when the flight mode will be entered.

<u>WSMR Area</u>

Evaluation and qualification of the propulsion subsystem for the Apollo spacecraft will be carried out at WSMR. CSTU's used to implement this program will have propellant servicing, reaction control, engine firing, gimbal control capabilities, and any other manual control and monitor capability necessary to qualify the propulsion subsystem.

[redacted]

LITTLE JOE II LAUNCH VEHICLE INTEGRATION

Draft copies of the procedural portions of the Apollo/Little Joe II interface coordination document (ICD) were coordinated with and tentatively approved by NASA and General Dynamics Convair. In addition, the mechanical interface and portions of the electrical interface have been delineated on ICD drawings and approved by Convair. These are being included in a report which will be ready for approval at the next S&ID/ Convair coordination meeting, scheduled for 15 December 1962.

The WSMR service tower drawings from architectural and engineering were reviewed and some modifications approved during a meeting at WSMR on 15 November 1962. A review of the other modifications is scheduled for 12 December 1962.

The GSE concept has been reviewed for compatibility with the WSMR abort test facilities. As a result, the cabling required to connect GSE on the service tower to the control room is being rerouted to a junction box more accessible from the service tower. Cabling from the junction box to the tower GSE will be installed by S&ID after the tower has been turned over to the operators.

Ballasting requirements for the Little Joe II boosted vehicles are under study. A heavy bulkhead across the adapter interface possibly can be used both as ballast and for protection to the payload from the tops of the rocket motor cases in the event of an abnormal abort.

Telemeter channel assignments have been coordinated with Convair, and NASA approval has been requested.

SATURN LAUNCH VEHICLE INTEGRATION

Assignment by NASA-MSC of responsibility to S&ID as custodian of interface coordination documentation was discussed at MSFC, Huntsville. The MSFC reaction was not favorable to the MSC directive, and so additional discussions between MSC and MSFC appear desirable to provide an atmosphere necessary for coordination and exchange of interface data.

A meeting between MSC, MSFC, and S&ID has resolved the mechanical interface load distribution between the instrument unit and the adapter for SA-6 and SA-7. Conclusions reached and tentatively accepted as current working information are as follows:

1. $q\alpha$ = 3700 psf-deg (max)

2. $C_{N\alpha}$ = 0.0556

3. Cp = 322 inches above instrument unit/adapter field splice.

4. Interface Loads

   (a) Shear = 20,700 pounds

   (b) Moment = 6.14×10^6 inch pounds

   (c) Axial = 108,300 pounds

5. Bolt Size = 5/16 inches diameter MS 20005, internal wrenching, heat treated 160 to 180 ksi

The above reflects a payload of 22,500 pounds plus 6600 pounds for the launch escape system. Because ballast requirements have not yet been firmly established, an unballasted boilerplate weight of 12,650 pounds payload plus 6500 pounds launch escape system was also calculated. The resulting interface loads are as follows:

1. Shear = 22,700 pounds

2. Moment = 7.21×10^6 inch-pounds

3. Axial = 88,700 pounds

4. Bolt Size = 3/8 inches diameter MS 20006, internal wrenching, heat treated 160 to 180 Ksi.

Modification of interface tooling to provide for the enlarged diameter bolts will be discussed with MSC and MSFC.

SWING ARM REQUIREMENTS

Information required by Launch Operational Center (LOC) for design of the swing arm at VLF-13 for boilerplate 13 has been developed and delivered to MSC for transmittal to LOC. Included were data on umbilical types and locations, cabling and fluid line requirements, umbilical plate design, tower junction box design, and water-glycol cooling unit installation requirements. This information is being incorporated in formal interface control documents.

Requirements for gaseous nitrogen purge during booster liquid hydrogen servicing operations have been transmitted to appropriate engineering design groups. Up-to-date copies of MSFC Document 10M01071, "Environmental Protection When Using Electrical Equipment Within the Areas of Saturn Complexes Where Hazardous Areas Exist, Procedure For," and the MSFC documents referenced therein are required to complete the design of the gaseous nitrogen purge system.

Design efforts will be continued to incorporate gaseous nitrogen purge, including line sizes and umbilical hardware. This problem is critical in light of LOC test hardware requirements.

LUNAR EXCURSION MODULE TRANSPOSITION AND DOCKING

A command module-lunar excursion module transposition and docking and crew transfer study was completed. Results of the study indicated that of the three transposition methods analyzed (free fly-around, tethered fly-around, and mechanical), the free fly-around method is preferred. This preference is based on the NASA established criteria of minimum weight, design and functional simplicity, maximum docking reliability, minimum time, and maximum visibility. Brief sketches of the three methods are shown in Figure (1). The quantitative results of the study are shown in Table (1), where the underlined values represent maximum or minimum results, and the preference for the free fly-around mode is readily apparent.

The free fly-around mode also represents the best selection from the standpoint of design and functional simplicity in that component parts and command module changes would be minimized.

Table 1. Transposition and Docking Study Results

Criteria	Free Fly-Around	Tethered Fly-Around	Mechanical
Structural weight, lbs	210	300	485
Docking reliability			
Translunar phase	0.9996	0.9988	0.9988
Lunar phase	0.9996	0.9996	0.9987
Docking time, min.			
Translunar phase	26	28	28
Lunar phase	23	25	23

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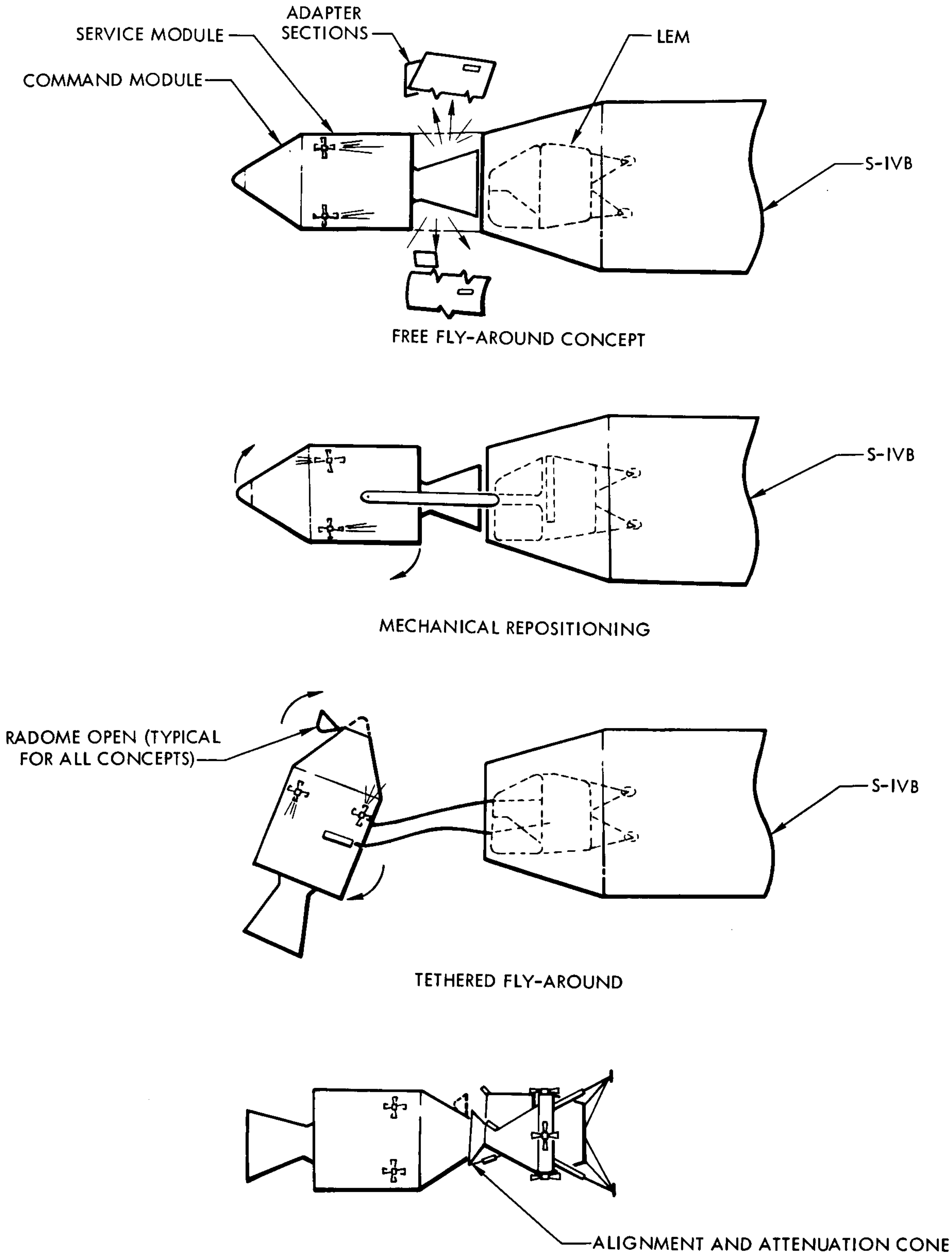

Figure 1. Command Module-Lunar Excursion Module Hard Docked Configuration

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[redacted]

Visibility during transposition and docking is essentially the same for all three modes. One possible exception exists for the emergency condition in the lunar phase when the command module (rather than the lunar excursion module) would have to be the active system. For this condition, the free flying and tethered modes would afford better visibility.

Transposition and docking while in lunar transit between the two Van Allen belts is recommended. This recommendation is based on the fact that the transit time between the belts is 31 minutes (26 minutes are required for transposition and docking); crew movement is acceptable, if required; GOSS trajectory confirmation could be made before commitment of transposition; also, an early deployment of the DSIF antenna and navigational sightings would thus be possible.

Primary objectives of the crew transfer studies were the determination of crew performance requirements, and, on the basis of these performance requirements, definitions of the human engineering requirements and attendant problem areas.

Spacesuit characteristics are of major importance to command module and lunar excursion module detail design and are critical to the transfer task performances. The design parameters which are directly affected by spacesuit characteristics are: (1) dimensions of access openings, (2) design of hatch covers, (3) location and operational design of hatch release mechanisms, and (4) physical arrangement of ingress-egress facilities.

In view of the undefined status of the spacesuit, the present study was not conclusive. Characteristics of the spacesuit will require further study before their effect upon crew performance of transfer tasks can be accurately assessed. Therefore, it is recommended that areas related to crew transfer between the command module and the lunar excursion module, and extravehicular activities be considered for additional study and testing, using simple mock-ups in most instances.

The desirability of a separate air lock within the lunar excursion module was investigated. Study results showed that such an air lock would impose a significant increase in complexity to crew movements and sequences involved in egress and ingress, and a 500-pound penalty on the injected weight of the vehicle.

As a part of this study, a comparison was made of the weight penalties associated with supplying the initial pressurization oxygen from the command module-service module environmental control system and from a separate lunar excursion module system. The approximate penalty was 13 pounds if the oxygen was obtained from the command module-service module system and 54 pounds if obtained from a separate lunar excursion module system.

[redacted]

[redacted]

Thus, it is recommended that a separate lunar excursion module air lock not be provided for crew transfer. It is also recommended that the capacity of the command module-service module oxygen supply system be increased to provide the initial lunar excursion module pressurization after completion of the transfer and docking operations.

SPACECRAFT OPERATIONAL SEQUENCE

Apollo spacecraft launch operations commence at T-7 hours with the filling of the reaction control system and service propulsion system nitrogen tetroxide tanks. Other servicing and checkout functions continue up to T-3 hours at which time the flight crew enters the command module. For the next 1.25 hours, the astronauts secure the module, check out crew systems, and participate in checking out other spacecraft systems. At T-1.75, the tower arms are removed (except for astronaut egress), after which the pad abort system is armed and the booster stages are serviced, first with liquid oxygen and then liquid hydrogen (the S-1C stage having been previously serviced with RP-1 fuel at T-18 hours). Ignition command is at T-0 hours with hold-down release at T+3.3 seconds.

Control of the launch operations is by the Launch Control Center at AMR until lift-off, at which time control is transferred to the Integrated Mission Control Center (IMCC) at Houston. Where possible, control of emergency procedures resides with the crew. For critical situations, however, provisions are made for abort control by IMCC or by automatic action of the crew safety subsystem. Further, if safe flight boundaries are about to be violated, a destruct command can be given by the range safety officer after prior warning of abort. The mechanization of these safety procedures has not yet been finalized.

During the phase up to launch tower jettison, the environmental control, electrical power, and communications subsystems are operating. The stabilization and control (SCS) rate gyros and the IMU are providing information, but are not in control of flight. The service propulsion system (SPS) and the service module reaction control system (RCS) propellant systems have been pressurized to permit their use in case of abort after the launch escape system (LES) has been jettisoned. Any emergencies that might produce abort are expected to originate in the launch vehicle. The only emergency in the Apollo spacecraft that appears possible as a cause for atmospheric abort is a failure in the service module propellant system.

The launch phase of the lunar landing mission is strongly dependent on the moon's position relative to the earth, and the criteria and limitations imposed by the launch site location and lighting during launch and lunar landing. For average lunar declinations, the launch window is about 4 hours in duration for those launch azimuth limits which are dictated by range safety.

[redacted]

A study to determine the feasibility of controlling the S-IVB guidance system from the command module and the transition of guidance function from the S-IVB system to the command module system will be continued during the next report period. Preliminary results favor the use of the command module guidance system for the control of injection into the translunar trajectory. A study of GOSS influence on such items as launch windows; number of orbits prior to injection and direction of injection into lunar orbit; and lighting requirements in launch, lunar landing, and earth recovery will be continued. Analyses of mission operations from LES jettison up to, but not including, translunar injection will be completed.

The launch trajectory for the lunar landing mission has been established to minimize aerodynamic loads and maximize payloads put in earth orbit. Maximum translunar injected payload is realized at the lowest possible earth parking orbit altitude which is limited by drag considerations.

Aerodynamic loads are minimized during that portion of the trajectory from boost to LES tower jettison by using a gravity turn (or by ascending at zero angle of attack for a no-wind condition). After tower jettison, which occurs above the sensible atmosphere, a special steering program is used to maximize payload to orbit.

The atmospheric transit of boost is accomplished by the first stage of the C-5 (S-IC). Following jettison of the S-IC, the second stage of the C-5 (S-II) continues the ascent trajectory. After S-II ignition and the booster and spacecraft have stabilized from the separation transit, the LES tower is jettisoned.

For design purposes, the maximum load factor and dynamic pressure angle of attack product have been determined using 3-σ variations in thrust, weight, drag, and a 99 percent probability wind shears.

Estimated sound pressure levels occuring on the spacecraft during boost have been determined from wind tunnel test data.

A time-line analysis of spacecraft operations will be issued, including preliminary requirements for GOSS support.

A revision of AMR program requirements will be issued.

[redacted]

[redacted]

ATMOSPHERIC ABORT

The LES, which is used for mission aborts in the atmosphere, utilizes an active rocket with a semi-passive directional control system. The LES requirements are:

1. Minimum altitude obtainable from a pad abort shall exceed 4000 feet.

2. Minimum range of 3000 feet at apogee shall be obtained from a pad abort.

3. The acceleration level during abort shall not incapacitate the astronauts.

4. There shall be no recontact with the booster following abort.

The LES designed to meet these criteria and requirements is shown in Figure 2. The system consists of a four-nozzle solid rocket motor, supported by a four-legged tower network mounted to the apex portion of the command module. Attached to the top of the main motor are solid propellant tower jettison and pitch control motors, and an aerodynamic fairing containing ballast. The direction of abort is fixed and controlled by the position of the pitch control motor thrust vector.

The LES operates over an altitude range of 0 to about 300,000 feet and is sequenced similar to that shown in Figure 3. Studies are currently under way to define the mechanism used to release the command module from the adapter, and the LES tower and the forward heat shield cover from the command module. Consideration is being given to either a mechanical or a dual explosive release mechanism.

The present LES design exceeds the pad abort altitude and range requirements and appears to meet the acceleration level and no-booster contact requirements. Two major problem areas exist: main rocket motor jet effects on the configuration's aerodynamic stability and, after tower separation, the two-directional trim characteristics of the command module. Wind tunnel tests designed to indicate the magnitude of the jet effects are under way. Wind tunnel, analytical, and structural design studies are being conducted to ascertain aerodynamic fixes to eliminate the undesirable command module apex-forward trim point.

A study will be continued to compare the use of the reaction control system and service propulsion system versus service module posigrade rockets for extra atmospheric abort.

Studies in progress will be extended, with emphasis on range safety, crew safety, and the concomitance of alternate and abort modes.

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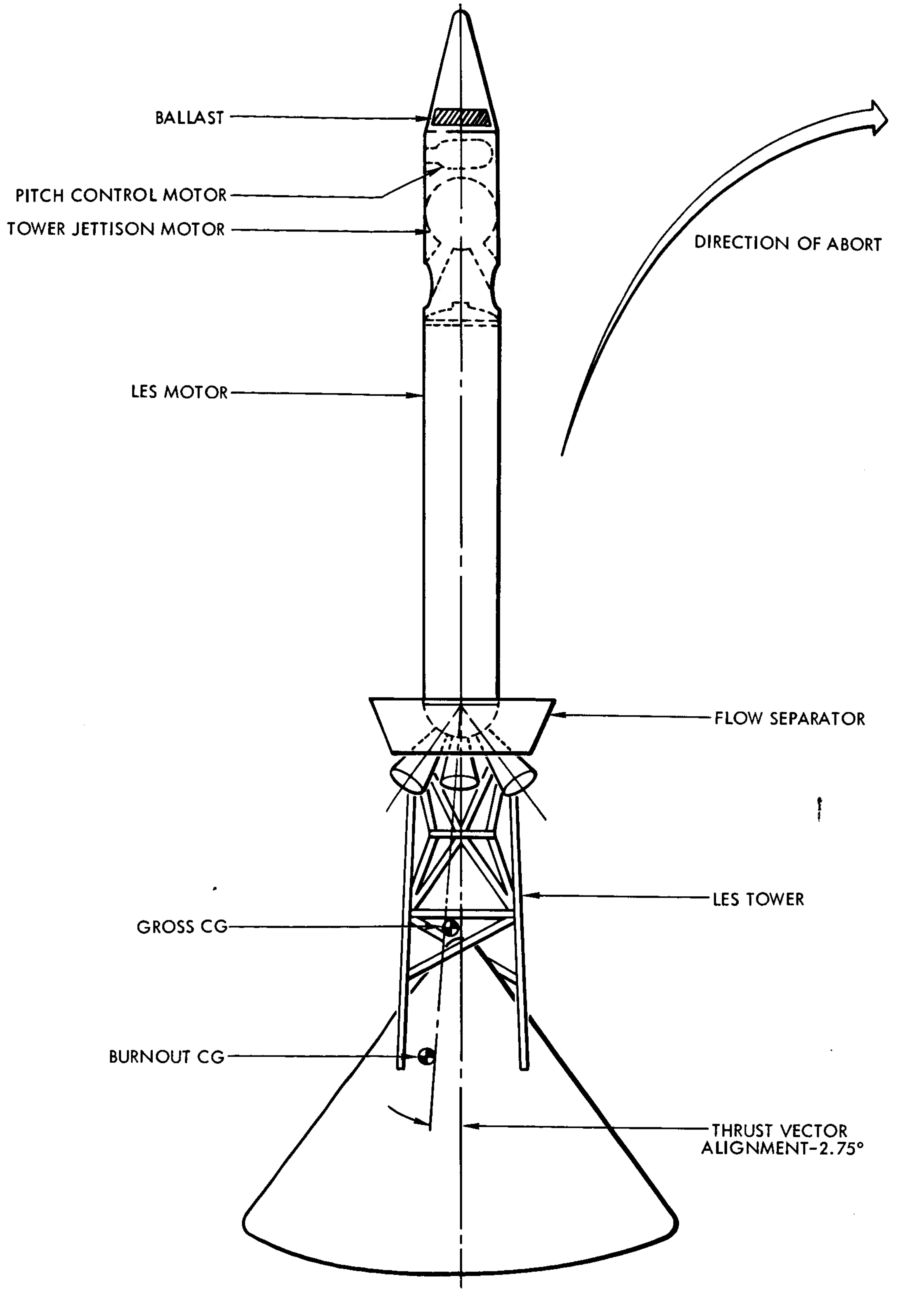

Figure 2. Launch Escape System Configuration

[redacted]

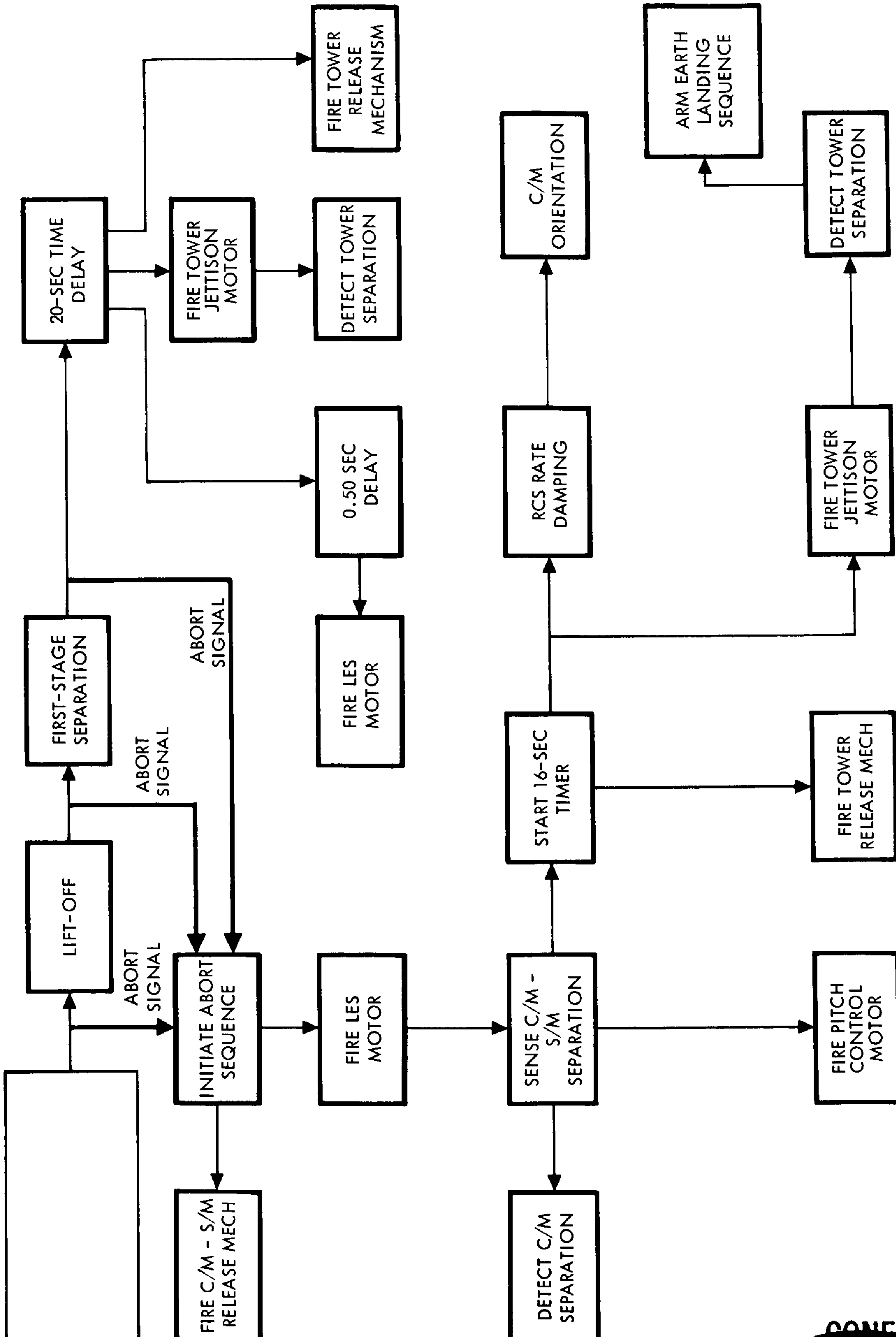

Figure 3. Launch Escape System Abort Sequence

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SYSTEM DYNAMICS

Milestones completed during November and those scheduled for December are shown in Table 2.

WIND TUNNEL PROGRAM

Static Force Tests

An investigation of several aerodynamic devices for elimination of the command module apex-forward trim point was conducted in the Jet Propulsion Laboratory supersonic wind tunnel. Nose flaps, webs, and spoilers located at the base of the command module were tested. The test Mach numbers were 0.7, 1.65 and 5.01; angles of attack varied from 0 to 168 degrees.

Tests to determine the static stability characteristics of the C-1 launch and launch abort booster configuration (FSL-1 model) were completed in the NAA trisonic wind tunnel. Data were obtained at high Reynolds numbers over a Mach number range of 0.4 through 3.5.

Dynamic Stability Test

Transonic dynamic stability tests of an updated launch escape vehicle model (FD-2) were completed in the Langley Research Center's 8-foot transonic pressure tunnel.

During the next period, the command module dynamic stability characteristics will be determined over an angle of attack range of -10 to 190 degrees. This type of data has never before been obtained for this angle range on this program. The tests will be conducted in the AEDC-VKF tunnels A and C over a Mach range of 2.0 through 10.0.

Pressure Distribution Test

Pressure distributions on the command module were determined over Mach number range 12 through 17 in the Cornell Aeronautical Laboratory (CAL) four-foot shock tunnel. These data will be used for correlation with the heat transfer test conducted.

[redacted]

Table 2. Apollo PMP Milestones

Flight Technology

Event No.	Milestone Description	Date	
		Schedule	Actual
21-019-D	Complete - Preliminary Command Module Aerodynamic Analysis	1 Nov 62	1 Nov 62
21-077-D	Complete - Preliminary ECS Optimization	1 Nov 62	1 Nov 62
21-080-D	Complete - Final Space Radiator Design Requirements	1 Nov 62	
21-084-D	Complete - Fuel Cell Prototype Preliminary Performance Analysis	1 Nov 62	1 Nov 62
21-076-D	Complete - Fuel Cell GSE Requirements	2 Nov 62	9 Nov 62
21-018-T	Complete - Flight Test Program Report for Aerodynamics	30 Nov 62	
21-022-D	Complete - Launch Escape System Jet Effect Wind Tunnel Test	30 Nov 62	
21-107-D	Complete - Preliminary Reqts. for Entry Flight System	30 Nov 62	
21-083-D	Complete - Environmental Control System Performance Criteria and Limitation	1 Dec 62	
21-108-D	Complete - Preliminary Orbital Ejection Service Module Abort Performance	1 Dec 62	

Table 2. Apollo PMP Milestones

Flight Technology (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
21-109-D	Complete - Preliminary Requirements for Rendezvous and Docking	7 Dec 62	
21-020-D	Complete - Saturn-Apollo Structural Dynamics Wind Tunnel Test	15 Dec 62	
21-110-D	Complete - GOSS Requirements - Earth Orbital Mission	15 Dec 62	
21-072-D	Complete - Cryogenic Storage Subsystem Bread Board Requirements	26 Dec 62	

Heat Transfer Test

Tests in the CAL four-foot shock tunnel to determine the heat transfer distributions on the command module were completed.

Structural Dynamics Program

The revised suspension system for the 0.08 scale model of the C-1 with Apollo spacecraft was completed. Ground vibration tests to determine frictional damping, measure mode shapes, and calibrated model instrumentation were completed. The model was shipped to the Langley Research Center for tests.

During the next period, tests will be completed to determine the aerodynamic and structural damping characteristics of the C-1 launch configuration model (SD-1). The tests will be conducted in the 16-foot transonic dynamics wind tunnel.

Drogue Chute Program

Subsonic wind tunnel tests were initiated to determine the stability and inflation characteristics of the drogue chute alone and in the presence of the command module. Chutes of varying porosities, diameters, and riser lengths will be tested.

During the next period, the dynamic stability of the drogue chute in the presence of the command module will be determined in the Langley 16-foot transonic dynamics wind tunnel.

Jet Effects Program

The FSJ-1, hydrogen peroxide jet effects model was installed in the Langley 16-foot transonic tunnel. The effect of the burning escape motor on the static stability characteristics of the launch escape vehicle will be determined. A catalyst pack that successfully decomposed the hydrogen peroxide was developed, and the test is proceeding according to plan.

Tests of the jet effects model will be completed during the next period.

FLIGHT PERFORMANCE AND CONTROL

Boost

Trajectory dispersions for the Saturn C-5 booster were completed. The dispersions from the nominal at launch escape subsystem jettison are:

Altitude (ft)	Range (NM)	Velocity (ft/sec)	Flight Path (deg)
+11,200	+2.6	+ 228	+ 0.9
-20,200	-3.7	- 342	- 1.3

The deviations in translunar injected payload capability due to perturbing the performance factor in each of the three stages in a like direction are +5617 pounds and -5052 pounds from nominal.

The C1B boost dispersions resulting from variations in thrust, I_{sp}, winds, and propellant mixture ratio were completed. The table below shows the maximum dispersions from the nominal at LES jettison are:

Altitude (ft)	Range (NM)	Velocity (ft/sec)	Flight Path (deg)
+ 11,500	+ 3.6	+ 289	+ .98
- 15,600	- 4.1	- 320	- 1.36

The maximum deviations in orbital payload at 100 nautical miles are 2931 pounds and - 2562 pounds from the nominal.

Trajectories were computed to determine the earliest point on the suborbital three-stage C-5 boost trajectory at which abort capability exists for using the service module propulsion system to attain earth orbit. For this, the S-IVB and lunar excursion module are jettisoned at abort. Capability will exist at liftoff + 480 seconds (84 percent through Saturn-II burning) and will allow sufficient fuel remaining in the service module to effect nominal earth orbit recovery.

Suborbital abort to orbit capability can be effected at the S-II point by utilizing for propulsion the boost stage combination of S-IVB and service module. In this case, the lunar excursion module is jettisoned with the expended S-IVB at service module ignition. On reaching orbit, the service module will have a ΔV remaining capability of 4500 feet per second.

[redacted]

The earliest point in the C-5 launch trajectory from which a suborbital abort to orbit can be effected by the S-IVB only also was determined. This capability will exist at liftoff + 378 seconds (58 percent through S-II burning). It will enable the lunar excursion module to be orbited along with the command and service modules for an alternate mission.

The Saturn aerodynamic loads analyses were completed. The results indicate the maximum $q\alpha$ values to be expected are 5822 and 7972 pounds per degree per square foot for the C-1 and C-5 vehicles respectively.

C-1 boost trajectories to a 100-nautical-mile orbit were computed for the current boilerplate weights as payload. A set of trajectories were chosen which will allow mission completion even though an "engine-out" condition could exist in either stage but not in both.

Saturn C-5 payload capability to translunar injection as a function of parking orbit altitude was determined. For the 100-nautical-mile orbit altitude point, the translunar injected payload sensitivity with altitude is approximately -77 pounds per nautical miles.

General separation equations for separation studies of the posigrade rocket installations were programmed for the IBM 7090.

An analog computer study to determine service propulsion subsystem (SPS) high-altitude abort capability and control requirements was completed. The study revealed that large phase shifts caused by the motor loop limits can cause system instability.

A study was initiated to define criteria for acceptable separation of service and command module. A safe separation distance between the service module and command module must be determined so that an explosion of the service module will not affect the command module during entry. An analysis, concurrent with this study, was initiated to define the separation distance that can be achieved for various retro maneuvers. Time and altitude are used as the limiting factor for return from lunar mission.

Space Operations

Tracking station data including time histories of elevation, range, azimuth, and their rates as measured from Goldstone, Johannesburg, and Woomera were produced for eight typical translunar trajectories out to approximately 30,000 nautical miles. The basic trajectories corresponded to long parking orbit coast trajectories resulting from launches with extreme azimuths for various lunar declinations.

The altitude decay of near-circular orbits about an oblate earth with a standard 1959 ARDC atmosphere was determined for a particular orbital inclination and ballistic parameter.

The lunar orbital altitude and lunar vicinity trajectory profile optimizations are approximately fifty percent complete. Lunar missions that do not include a landing on the lunar surface (i.e., lunar orbit mapping missions) were found to have performance-optimal finite circular altitudes dependent on translunar and transearth transit times and plane change requirements. Lunar landing missions were found to require the lowest possible lunar parking orbit altitude for optimal performance using practical lunar excursion module weights and reasonable translunar and transearth transit times. An investigation of four lunar excursion module descent profiles in terms of translunar injected weight requirements, operational considerations, and abort requirements was initiated.

A preliminary investigation of lunar landing site and trajectory event lighting for the year 1967 was completed. With respect to reasonable abort and lunar landing site lighting restrictions, available launch times were found to be severely reduced during certain months of the year. Continued analysis using the lighting wheel indicator is planned.

A six-degree-of-freedom, closed circuit TV simulation of transposition and emergency docking maneuvers has been in progress. Data analysis indicates free-flying docking is feasible, and an auxiliary alignment aid is beneficial to the pilot in reducing contact conditions.

Launch vehicle trajectory dispersions are being computed for the Saturn/Apollo C-1 and for C-1 service module configurations. These dispersions are based on three sigma variations in thrust, I_{sp}, drag, usable propellant and wind profiles obtained from Patrick Air Force Base.

Three-degree-of-freedom boost vehicle trajectories for an oblate earth will be determined using various launch azimuth headings for flight test planning. The payload capability obtained will be correlated with payloads previously computed using a two-degree-of-freedom, east-launch, optimum-steering program.

Equations will be formulated for an optimum-steering, three-degree-of-freedom computer program.

Finite burning trajectories and performance capability will be determined for abort during translunar injection back to earth orbit. Further studies will determine abort capability back to a safe atmospheric entry.

Studies in the following areas of boost dynamics will be initiated as requirements and problem areas are more clearly defined: emergency detection system, S-IVB Abort, and service module abort (posigrade system).

The circumlunar trajectories analysis report will be completed.

Optimization will be completed of the lunar vicinity trajectory profiles from a performance and operational considerations standpoint.

The optimization and calculation of ΔV requirements for arbitrary lunar landing site locations achieved by non-free return trajectories will be continued.

Data from the docking simulation will be reduced, analyzed, and a preliminary report issued. Plans for a rendezvous simulation will be implemented.

Entry and Recovery

A survival guidance display concept was defined for atmospheric entries from lunar missions. This concept includes both safe entry and retrieval criteria.

Non-optimum shaping of the boost trajectory to reduce entry deceleration during exo-atmospheric abort and/or reduce touch down site requirements was analyzed. As a result of this analysis, reshaping of the boost trajectory is not recommended.

Heating loads for a 5000-nautical mile overshoot, "controlled-range" MIT entry were calculated. These trajectories resulted in a 13 percent lower heat load than in the HSE-3A design trajectory.

Preliminary entry requirements, emergency flight modes, and retrieval area requirements will be defined for entries from lunar missions. The use of the S-IVB for exo-atmospheric abort (C-5) will be investigated. Separation of the service module from the command module will be investigated with regard to entry miss distances, separation ΔV requirements, and separation time prior to entry.

Interrelated Mission Studies

The flight performance and control requirements for monitoring of the navigation and guidance system were established. Position and linear velocity should be transmitted from the on-board computer to the ground in the XYZ computer axis reference system. Attitude and linear accelerations should be transmitted in the stability axes reference system during the entry phase and in the inertial platform reference system during all other near-earth flight phases.

AERODYNAMICS AND AEROTHERMODYNAMICS

Configuration Studies

Two wind tunnel investigations to determine modifications to the command module, which will eliminate the second trim point, were completed covering the Mach number range from 0.7 to 5.0. The configurations investigated are as follows:

1. Various flaps, cylinders, or cylindrical segments mounted at the apex of the command module.
2. Blunt apex.
3. Web or web-like flow separators mounted on the afterbody surface parallel to the conical axis.
4. A spoiler mounted on the command module heat shield.

The flap and web (or strake) were selected for additional study. This selection was based on an analysis of initial test results.

An analysis of the pressure distributions on the command module revealed that a spoiler mounted on the entry heat shield could be a very effective destabilizing device. Pressure data measured at angles of attack greater than 50 degrees indicated that pressure coefficients as low as -1.6 are developed near the leading edge of the heat shield. This compares with a base pressure level of about -0.6 at low angles of attack. By preventing the large negative pressure on the base of the command module, the stability at angles of attack from 50 to 90 degrees could be significantly reduced. Consequently, wind tunnel investigations of this device were initiated.

Preliminary aerodynamic coefficients for a nose flap and the strake configurations were prepared. These configurations are being evaluated for effectiveness to destabilize the command module in the apex-forward attitude.

During the next period, the command module apex-forward trim configuration studies will be completed.

Studies will be continued to determine design modifications that will augment the entry lift/drag capability.

Stability

Aerodynamic damping derivatives obtained from an analysis of wind tunnel data were measured by the free and the forces oscillation test techniques. Derivation of the required equations for reduction of the data obtained in the free oscillation technique was completed.

An analytical method of transferring the measured aerodynamic damping derivatives $(C_{mq} + C_{m\dot{\alpha}})$ of the command module from the test center of rotation to an arbitrary center of rotation was derived. This transfer is required because the center of rotation in wind tunnel tests of dynamic stability generally does not coincide with the command module center of gravity.

Studies will be extended to determine the effects of center-of-gravity offset on the damping characteristics of the command module and launch-escape vehicles.

Air Loads

The analyses of air loads for nine components of the launch escape vehicle were completed. The results are based on data obtained in recent multiple balance tests at Mach numbers 0.7, 1.1, 1.55, and 2.0. A complete angle-of attack range of 0 to 180 degrees is covered in the analysis.

The pressure distributions on the command module for the launch escape configuration were prepared. These data, required for the final analysis of boilerplate 6, are representative of the maximum design load condition for this test operation.

An analysis of the pressure distribution on the flow-separation disk of the launch escape vehicle was completed for Mach numbers 0.7, 1.2, 1.55, 1.8, 2.0, 2.5, and 3.0. The angle of attack range is from 0 to 169 degrees. These data constitute criteria for local design of the flow-separation disk.

An analysis of the boost phase internal pressure for a vented service module and adapter was completed. The results of the study give peak pressure across the vent as a function of chamber volume and vent area. Typical chamber pressure-time histories are presented for the boost trajector. The analysis reveals also the effects of deviating from the nominal boost trajectory. Recommendations for vent fairings and location of vents have been made.

Flow Fields

A method to determine the angle of the separated flow region behind the command module at zero angle of attack was established. It is based on considerations of matching the pressure behind the inclined shock wave at the neck of the wake with the stagnation pressure on the dividing streamline in the shear layer. Wake angles were calculated for four of the 15 conditions considered on the entry trajectory of the command module. A computer program has been written.

Calculations for the supersonic inviscid-flow field on both the upper and the lower sides of the command module in the entry attitude were completed for the 25, 500 feet per second/200, 000 feet altitude case. The chemical rate equations for dissociating and ionizing air were prepared for programming. The chemical model used includes 40 chemical reactions that can affect the thermodynamic properties of air and is considered a valid model up to escape speed. The program will be coupled to the flow equations and will, in effect, replace the ideal or equilibrium real-gas thermodynamic properties.

During the next period, the flow field on the top and bottom sides of the command module will be calculated by the characteristics method for some additional points in the entry trajectories. The criteria defining whether the flow is frozen or in equilibrium will be computed. A digital program will be initiated to compute the instantaneous composition of the air surrounding the command module during entry, allowing for non-equilibrium chemical reactions.

Plume Effects

Studies were initiated to compute pressure distributions due to impingement of an exhaust stream on an adjacent surface. The subroutine which computes the streamlines and Mach number distributions in a jet plume by characteristics method was successfully programmed and gave excellent results up to 20 radii downstream. This subroutine is applicable to low external pressures (down to vacuum conditions) and allows for the backward expansion of the characteristics and streamlines.

The problem was formulated in such a way that simple modifications could be made to incorporate the shock wave inside the plume, real-gas thermodynamic properties (i.e., variable gamma), arbitrarily varied Mach numbers, and entropy and enthalpy distributions at either the exit plane or the exit Mach cone.

Flight Environment

A report titled "Particulate Environment in Solar Space — Some Effects of Earth's Gravitational Field" was prepared to clarify some of the ambiguities in available information and to fill voids in such information.

Work will be continued on the Apollo Natural Environment Manual during the next period. This manual presents a description of 27 natural environments applicable to design, test, and operational phases of the Apollo mission. The environments are separated into those for the earth's surface, earth's atmosphere, and the cislunar space and lunar surface.

Aerothermodynamics

Heating rates to the Apollo vehicle surfaces were recalculated for all flight phases of existing design trajectories. These heating rates reflect an increased command module weight (up to 9500 pounds).

Hardware items mounted internal and external to the surfaces were also investigated to determine aerodynamic heating loads. These items and the corresponding maximum heating rates estimated are as follows:

1. Command module window on most leeward meridian: 6 Btu per square foot per second
2. Command module parachute packs for abort at an altitude of 80,000 feet: 1.6 Btu per square foot per second
3. Posigrade rocket fairing and nozzle: 4 and 7 Btu per square foot per second, respectively
4. Air lock cover seals: 1.6 Btu per square foot per second

Plume-impingement heating caused by firing the service module reaction control system (RCS) engine was also investigated relative to the service module surface and antenna. The engine considered was a 100-pound thrust rocket with the nozzle canted at an angle of 10 degrees and located 8.25 inches above the service module surface. The results indicated a maximum heating rate of 4 Btu per square foot per second to the module surface and a maximum value of 7 Btu per square foot per second to the service module antenna.

Correlation of analytical methods and wind tunnel test data from the JPL test was extended to the windward regions of the entry afterbody. Similarly, an investigation of the separated leeward region of the entry afterbody was initiated to correlate theory with data from the Langley Research Center.

Gas-cap radiation estimates to the command module are being reevaluated because of the following modifications:

1. Redefinition of the shock shape based on experimental and analytical results obtained at the Ames Research Center.

2. Inclusion of self-absorption effects within the shock layer.

The first part of the command module RCS heating test was completed. This portion of the test used a full-scale model of the rocket nozzle. The second part of the test is being prepared and will use a one-third-scale model of the nozzle. The variation in model size will extend the range of the important ratio boundary layer height to nozzle exit diameter.

Analyses will be continued during the next period to improve the entry heating program and calculate Reynolds number, shear stress, pressure, temperature, and laminar and turbulent flow conditions for body points on the entry face and along the 45, 90, 135, and 180 degree meridians of the afterbody. The analytical correlation of experimental data will be extended to the leeward region of the entry configuration afterbody. The discrepancy between S&ID's heating rates and those of Langley Research Center will be resolved.

Analyses will be continued to correlate the command module RCS entry-heating test data with theory, thus completing the second half of the heating program.

The service module RCS plume-impingement heating test will be completed.

An analysis of the boundary layer on the command module will be initiated as part of a study of the separated region behind the command module during entry.

CREW PROVISIONS

REQUIREMENTS AND ANALYSIS

Milestones completed during November and those scheduled for December are shown in Table 3.

CREW OPERATIONS

Crew Performance and Training

Specific human factors data have been prepared for the procurement specification on the full-mission simulator.

Human factors' requirements for the part-task trainers, in which the features planned for three trainers would be combined in two trainers, have been completed during the report period.

Task Design and Analysis

Maintenance performance capabilities and limitations of the crew members in-flight were compiled.

Information decision action (IDA) logic flow diagrams have been initiated for the following systems:

Environmental control system (ECS)

Service module reaction control system (for interfaces with navigation and guidance and stabilization and control systems (SCS)).

Service module service propulsion system (for interfaces with navigation and guidance and SCS).

These diagrams are being made as part of the preparation for the transearth injection phase of Apollo. The task element list for this phase has been updated.

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Table 3. Apollo PMP Milestones

Crew Provisions

Event No.	Milestone Description	Date	
		Schedule	Actual
31-034-D	Complete - Release of Layout and Preliminary Design of Crew Accessories and Survival Equipment	26 Oct 62	2 Nov 62
31-095-D	Start - Digital Programming of Task Analysis Data	1 Nov 62	1 Nov 62
31-099-D	Start - Analysis of Crew Duty Stations Work Load	1 Nov 62	1 Nov 62
31-114-D	Complete - Establishment of Organization and Procedures for Coordinated Review and Resolution of Safety Problems	1 Nov 62	15 Oct 62
31-135-D	Start - Crew Support (Couch, Suspension and Restraint) Human Engineering	1 Nov 62	15 Oct 62
31-137-D	Start - Part Mission Crew Performance Simulation Tests	1 Nov 62	1 Nov 62
31-010-D	Complete - Release of Waste Management Fixtures Design for Boilerplate 14 House Spacecraft	2 Nov 62	17 Aug 62
31-046-D	Complete - Design of Flight Crew Display Panels for Mock-up 18	15 Nov 62	8 Nov 62
31-052-D	Complete - Release of Design of Crew Compartment Interior Lighting Fixtures for Mock-up 18	15 Nov 62	15 Oct 62

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Table 3. Apollo PMP Milestones

Crew Provisions (Cont)

Event No.	Milestone Description	Date Schedule	Date Actual
31-077-D	Start - Investigation of Biomedical Aspects of Crew Work-Rest Cycles	15 Nov 62	5 Oct 62
31-089-D	Start - Medical Monitoring of Simulation and Tests	15 Nov 62	7 Sept 62
31-133-D	Start - Crew Provisions Developmental Tests	1 Dec 62	20 Nov 62
31-131-D	Start - Preliminary Crew Performance Analyzer Tests	15 Dec 62	

A correlated missions task index has been completed.

Biomedical

A statistical analysis of Mercury candidate selection physical fitness tests has been completed. Preparation of a final statement on medical qualification procedures for Apollo simulation and test subjects has been initiated.

A report presenting life systems comments on high g entry acceleration profiles for spacecraft with lift/drag ratio of 0.5 and entry angles of -7.72, -9.0, and -10.0 has been prepared.

During the next report period the medical selection of simulation and test subjects will be initiated.

CREW EQUIPMENT

Personal Equipment Requirements

An analysis of the astronauts' body dimensions has been initiated for use in evaluating astronaut comments during mock-up inspections.

Revisions to the Apollo crewman mannikin drawings have been completed.

An evaluation of five types of restraint harnesses has been initiated.

Harnesses used on the B-70 and X-15 programs are being evaluated; in addition, a continuous webbing harness, a harness integrated with the pressure suit, and the design presented by the Columbus division of NAA are being considered.

In-flight test probe clearances were tested and recorded, using a 90th percentile subject in a Mark IV pressure suit. The subject was able to insert a 5-1/2 inch probe into all areas of the patch panel at 3 psi suit pressure.

Freeze-dehydrated foods have been packaged for the environmental habitability performance simulation. These foods are being analyzed.

Spacecraft Design Support

The storage area for lithium hydroxide canisters has been moved to the lower equipment bay, making the right-hand equipment bay and aft food-storage compartments more accessible.

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Life systems illumination requirements have been prepared.

Fabrication and testing cost estimates for the life systems arm simulator were completed.

Ground Control Support

The schematics of the service module reaction control system (RCS), the service propulsion system (SPS), and the command module RCS are being reviewed for location of GSE checkout points.

CREW SIMULATION AND TEST

Test Requirements

The life systems land and water general impact test procedures have been revised. The life systems program will be presented to NASA as part of the integrated requirements for the boilerplate 1 and 2 test programs.

Test Program

A life systems human engineering and limited crew performance test program, to be conducted during hot firing of the service module and RCS propulsion systems, will be included in the development and qualification of airframe 1.

This is the only test program in which an actual demonstration of crew performance with operational propulsion system hardware and controls and displays can be conducted prior to the first manned flight.

Performance Analyses

A preliminary draft of definitions and objectives for the life systems crew performance analyzer has been completed.

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NAVIGATION AND GUIDANCE INTEGRATION

REQUIREMENTS AND ANALYSIS

The functional requirements for the navigation and guidance interface specification were completed.

Entry Guidance

The gravity versus time survival guidance system was simulated in a digital computer program. Touch-down errors are being investigated, including uncertainties in acceleration and time measurements, initial time, roll-angle measurements, and transport time delays.

Orbital Navigation

The problem of required frequency of platform alignment is being analyzed as a function of gyro drift, mapping uncertainty, and initial platform misalignment. An optimum time to realign the platform was determined for out-of-plane data, smoothed by the least-squares filter (with infinite gyro correlation time). An S&ID report on orbital navigation techniques and error analyses was completed. The covariance matrix of orbital errors will be propagated for varying orbital stays (with navigational sightings).

Midcourse Abort Guidance

An analytical derivation of the transition matrix elements for midcourse was derived. The close forms are very cumbersome and do not appear to lend themselves readily to on-board navigation. A method of arriving at the transition matrix elements, using small perturbations in the state vector, is being prepared for purposes of simulation and error analysis.

Navigation Sighting Analysis

The constraints on vehicle orientation for navigation sightings were prepared to obtain a working model. These parameters will also be incorporated into several programs to obtain an optimum profile for an Apollo mission. The navigation sighting evaluation (Phase I) was completed using an analog-driven simulated sextant. Preliminary data indicated great difficulty in obtaining a 10 seconds of arc accuracy for sextant sightings using the lunar limb and a particular star image.

The navigation sighting procedures and accuracies will be determined during the next report period. Optical studies will be conducted, using life systems criteria and certain simulations, to determine the appropriate vehicle maneuver controls required during optical sightings.

Control Display Unit (CDU) Analysis

The mathematical model for the inertial measurement unit, IMU/CDU, was derived. It appears that small angle approximations and modified Euler angle transformation will have a deleterious effect on large attitude change maneuvers. A Fortran program was prepared to evaluate these effects and to determine acceptable limits.

The steering command limits for vehicle attitude change will be established during the next report period.

Guidance and Control Digital Closed Loop Simulation

An analysis of numerical techniques to be employed in representing the stabilization and control subsystem (SCS) was completed. The attitude gyro coupler (AGC) simulation was completed.

Attitude Gyro Coupler Guidance Mechanizations

The AGC interpretive routine study was completed. A report was prepared describing the methods used in the AGC program.

During the next report period, an IBM 7090 closed loop simulation will be made available for the first AGC guidance mechanizations.

Covariance matrixes will be obtained for various points along the ascent trajectory. These errors will then be propagated along abort trajectories to obtain more realistic errors at the entry interface.

Preliminary results of the MIT IMU error analysis will be completed. These errors include uncertainties in gyro drift, acceleration measurements, initial alignment, initial conditions, computer error, random vibration, and temperature gradients.

DESIGN STATUS

The configuration of the navigation and guidance controls and displays in the lower equipment bay was approximately 70 percent resolved. This status will be reflected in the mock-up for boilerplate 18. The locations of panels and planes were established and are reflected in an interface control drawing (ICD). The installation interface for the navigation and guidance navigation base and optics attachment to the pressure hull are also reflected in an ICD.

The operational measurements will be compiled into data groups to assist in planning data recovery for specific flights. These measurements will also be grouped and further defined to assist in the planning of GSE and integrated checkout procedures.

RELIABILITY STATUS

Table 4 lists the components of the navigation and guidance subsystem with their predicted failure rates, mission time for the components, the predicted reliability without redundancy, the predicted reliability based on redundancies proposed, the reliabilities, and the factors of criticalness.

The values of apportioned reliability are based upon alternate modes of operation. Studies are presently being conducted to determine the optimum number of spares for a range of electronic subsystem weights. The apportioned reliability will be achieved from the in-flight maintenance and spares concepts generated by these studies.

Preliminary failure-mode analyses, using combined guidance and control system capabilities, were partially completed. To assist in these studies, functional block diagrams were prepared that define the configuration of the guidance system during various mission modes of operation.

[redacted]

Table 4. Navigation and Guidance Subsystem

Equipment	N 10^{-6}	Time Hrs.	Predicted Reliability No Redundancy*	Predicted Reliability Proposed Redundancy*	Apportioned Reliability**	Criticalness Factor***
Inertial measuring unit	821.60	39.85	0.967766	0.967766	0.998976	0.081418
Power servo assembly	36.82	39.88	0.998532	0.998532	0.999925	0.080842
Coupling display unit	122.40	39.88	0.995119	0.995119	0.999742	0.080984
Apollo guidance computers	41.14	66.07	0.997282	0.997282	0.999739	0.081224
Sextant	100.52	55.02	0.994469	0.994469	0.999845	0.858461
Scanning telescope	11.60	55.02	0.999362	0.999362	0.999909	0.080827
Total	—	—	0.953132	0.953132	0.998136	—

*These calculations were based on the Minuteman generic failure rates.
**These calculations used sensitivity indices as a basis for apportionment.
***These calculations were based on a partial derivitive, from the mission phase logic diagrams, for crew safety with respect to the component.

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SPACECRAFT RELIABILITY

PROGRAMS

Reliability support has been provided on four major program review tasks undertaken during the report period: redefinition of qualification testing, review of design criteria, revised GSE concept to incorporate SPACE, and reduced documentation.

Reoriented Qualification Testing

The test program was reoriented as a part of a cost-reduction effort to provide a qualification program that thoroughly evaluates the capability of the system or component design. The qualification-testing program will provide data, development tests, boilerplate-spacecraft tests, spacecraft-ground tests, and spacecraft-flight tests, to make reliability assessments. This plan was presented to NASA during the report period. NASA concurred in the S&ID recommendations.

The objectives of the qualification test program are achieved by employing fixed-design development-test results, allowing qualification by similarity, defining test-program scope clearly, selecting minimum test criteria and utilizing refurbished test articles when feasible. The basic ground rules used to define the qualification-test plan are:

1. Zero-failure criteria
2. Reliability demonstration no prerequisite for qualification
3. No test duplication at higher level of assembly
4. Test at a practical level of assembly
5. Minimum testing by subcontractor's suppliers
6. Qualification prior to first manned flight
7. Tests based on engineering rationale in lieu of statistical rigor

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A minumum qualification program was defined to include at least three black boxes on lower assemblies for environmental and off-limit testing plus one subsystem for mission simulation and life testing. Requirements for hardware, over and above this minimum program, are justified on the basis of criticalness, expected use, and required service life. In the majority of cases, the number of items for test were significantly reduced.

Test Philosophy

The qualification-test philosophy and plan outlined herein is considered by S&ID (and concurred in by NASA) as the approach most compatible with NASA budget, Apollo engineering, and mission success. This reorientation and reduction in qualification testing resulted in a complete redefinition of the level of assembly to be tested, the number of test articles, environments, time of exposure, and criteria for qualification.

This test plan is considered to be an absolutely minimum program. Based on zero failure criteria, contingencies resulting from failures, the necessity for corrective action by redesign, and program changes have not been provided for in the cost. During the next period, revised requirements for ground testing will be incorporated into specifications and work statements and submitted to subcontractors for firm pricing. The rewrite of the qualification test plan will be initiated. A working committee will be established to implement a detail parts-improvement program. The first actions of the committee will be to determine the status of each subcontractor program. All parts-improvement programs which have been initiated or proposed, will be screened to eliminate duplication of effort. The educational TV courses "Reliability Indoctrination for Designers," and "Reliability Indoctrination for New Hires" will be completed. The initial reliability/crew-safety review program will be conducted. It will deal with the tower separation system.

DESIGN CRITERIA

Design criteria have been reviewed with attention concentrated on environmental criteria, redundancy, alternate modes of operation, spares provisions, and reliability and crew-safety probabilities.

Environmental criteria have been revised to redefine limits for operating and non-operating conditions.

DOCUMENTATION

A review of subcontractor documentation requirements resulted in the deletion of general test plans, monthly failure summaries, and separate quarterly reliability-status reports.

Requirements formerly separated into individually unrelated test plans will be met by separate volumes on test logic, development, qualification, acceptance, and multiple-systems tests. The composite of these volumes will constitute the over-all test plan for Apollo.

S&ID will machine-code individual failure reports and will integrate this data into monthly summaries. This procedure replaces the one which required subcontractors to submit monthly failure summaries.

The requirement for a quarterly reliability-status report will be met by a separate section in the monthly progress reports. This will assure more timely reporting of reliability and crew-safety status.

Reliability Education

A closed circuit educational TV program is being initiated. The first program will be a reliability-mathematics course.

Crew Safety Review

The reliability/crew-safety review program, as delineated in the reliability program plan is being implemented. The initial review will encompass all aspects of the design to identify problem areas which affect quality control, manufacturing, operations, maintenance, man-machine integration and mission success, and crew-safety reliability.

Translunar Transposition and Lunar Docking

Three methods of accomplishing translunar transposition and lunar docking operations have been analyzed. See Tables 5 and 6 for design and performance considerations. The methods studied were transposition and docking with the lunar excursion module mechanically restrained; a free fly-around spacecraft with the lunar excursion module stabilized by the Saturn-IV-B vehicle, and then with the lunar excursion module self-stabilized; and a tethered lunar excursion module which first involves capture by the spacecraft.

None of the configurations evaluated met the required reliability.

Tables 5 and 6 summarize the results of the analyses and delineate reliability requirements.

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Table 5. Translunar Transposition

Configuration	Predicted Failure Rates Failures/10^4 Missions
1. Mechanical Mode	57
2. Free Fly-Around	
A. Lunar excursion module Stabilized by S-IVB	80
B. Lunar excursion module Self-Stabilized	80
3. Free Fly-Around Tethered Lunar excursion module	80
Required Reliability: 0.998 (20 Failure/10^4 Missions)	

Table 6. Lunar Docking

Configuration	Predicted Failure Rates Failures/10^4 Missions
1. Mechanical Mode	187
2. Free Flying Mode	165
3. Free Flying Mode Tethered Lunar excursion module	165
Required Reliability: 0.998 (20 Failures/10^4 Missions)	

One method for improving the over-all system reliability is by making allowance for the depressurization of the command module to enable an astronaut, acting as an alternate mode in the event of mechanical system failure, to transposition the lunar excursion module. A second method is the elimination of the requirement for hard docking at rendezvous. Deletion of the hard docking requirement would require crew transfer to be effected in the free-space mode.

A large improvement is expected if the proposed methods prove feasible. Specific reliability numerical values have not been calculated. The feasibility of improving over-all system reliability by enabling man (as an alternate mode) to transposition the lunar excursion module, and by eliminating the requirement for hard docking at rendezvous, will continue to be investigated.

QUALITY CONTROL

Review of Subcontractor Documentation

The quality control plan of Northrop-Ventura was reviewed and approved. Reviewed for quality provisions were 4 subcontractor end-item test plans, 1 special sampling plan, and 27 other types of approval documents.

Specifications

A total of 27 procurement specifications were reviewed prior to release and quality assurance provisions provided for three specification control drawings.

A quality control specification, Inspection, Radiographic, has been developed and will be submitted to NASA for review prior to release.

Inspection and Test Planning

A total of 1395 FAIR tickets were reviewed and authorized by Quality Control.

Quality Control Laboratory

An evaluation is being performed on an electrolytic removal process to be used prior to brazing the honeycomb to the facing sheets of the command module sections. Preliminary tests indicated that complete removal of residual silver braze alloy can be accomplished by this process in a matter of minutes. Continued investigation is being performed on past cleaning operations and the effect of residual salts on weld contamination.

Training and Certification

The training department has published a report entitled "Division, Program, Functional Training Requirements and Courses Designed to Meet These Needs". This publication will facilitate the uniform implementation of the quality assurance training program.

The nonconformance reporting system training program has produced the desired results and the system is now implemented.

An operational training course in dye penetrant inspection has been developed by the training department in conjunction with the quality control laboratory. Inspectors are also being scheduled for certification in welding inspection and recertification in soldering inspection.

Supplier Evaluation

Thirteen manufacturers were surveyed for adequacy of their quality control systems. The products involved were honeycomb skins, expulsion tanks, ground cooling carts, and electrical and hydraulic units. Ten of the firms were approved. The forecast for the next report period indicates the requirement for surveying 20 potential suppliers.

Major Subcontractors

Representatives of the major subcontractors attended meetings held at S&ID, Downey, during which the following major problem areas were noted:

(1) The increased cost of identification and traceability, particularly with respect to the large concerns who furnish electronic components

(2) Some contract cost increases due to the documentation requirements of NCP 200-2

(3) The necessity of some relief from NCP 200-2 on certain suppliers whose products should not be termed as a system requiring full NCP 200-2 compliance

(4) The need for NASA to give more positive direction to the supplier's cognizant agency

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Receiving Inspection Planning

The receiving inspection planning group released approximately 100 inspection and test procedures to be used by receiving inspection.

Product Inspection

The first land drop of boilerplate 1 resulted in major damage to the heat shield and minor damage to the command module. Damage to the command module consisted of several dents in the aft bulkhead and cracking of one weld. The 50 G accelerometers attached to the unit were tripped as were the 15 G accelerometers attached to the crew couches.

Command module boilerplates 3 and 19 were accepted in their structural stages and are now in final assembly. The stacking of the complete mock-up 9 was also accepted.

Quality Evaluation and Audit

During this report period, 35 audits, (consisting of 417 observations) were conducted. Corrective/preventive action was initiated on 55 items. Action was completed on 31 of these items, with remedial action in progress on the remainder. Nine reaudits were completed in previously deficient areas. The reaudits confirmed the correction of previous discrepancies.

Material Review

A quality assurance operating procedure covering material review organization, authority, and disposition has been published. This procedure was developed specifically for NASA programs and will broaden the scope of material review board action.

Nonconformance reports (NCR) are being processed in compliance with NCP 200-2. Nonconforming material is being reviewed by representatives of NASA and S&ID. Corrective actions are being directed to the responsible departments and to the quality control laboratory for updating of process specifications to the latest advancements in techniques and equipment.

STABILIZATION AND CONTROL SUBSYSTEM

REQUIREMENTS AND ANALYSIS

Milestones completed during November and those scheduled for December are shown in Table 7.

Thrust vector control autopilot analog simulation results have been published. These results show that limiting the nozzle angle increases system stability, but that limiting the angular velocity and acceleration of the nozzle tends to decrease system stability.

Results of an actuator-clutch-driving system analysis for the service module propulsion system are summarized as follows: The individual torques required of a four-clutch-driving system are the same as those in a two-clutch-driving system. The four-clutch-driving system which was studied had almost identical control characteristics before and after the failure of one clutch.

Analytical and simulation studies were conducted to determine the effects of the reaction control system (RCS) engine thrust dynamics and the stabilization and control system (SCS) switching logic upon propellant requirements for the command module. The recommended values for engine thrust, roll-rate limit, and propellant requirement are 100 pounds, 20 degrees per second, and 100 pounds respectively.

Studies are now in progress to evaluate tradeoffs between propellant consumption for the command module and rate deadbands for the critical portions of the entry flight regime. Performance is compared on the basis of propellant consumption, stability, and g-load. Disturbance sources of particular interest are wind shear, negative $\dot{q}$, and dynamic-stability coefficients.

Entry simulation studies conducted during the next report period will be directed toward the determination of an allowable command module RCS minimum impulse and an evaluation of the cumulative effect of command quantizing and rate deadbands on propellant consumption. A digital simulation of the 6-degree-of-freedom entry problem is being prepared.

Table 7. Apollo PMP Milestones

Stabilization and Control Subsystem

Event No.	Milestone Description	Date	
		Schedule	Actual
30-002-D	Complete - Spacecraft Stabilization and Control System - Requirements Definition	5 Nov 62	19 Nov 62
30-016-D	Complete - Spacecraft Stabilization and Control System - Accelerometer Package Specifications	14 Nov 62	
30-020-D	Complete - Spacecraft Stabilization and Control System - Rate Gyro Package Technical Design Space	14 Nov 62	
30-021-P	Complete - Spacecraft Stabilization and Control System - Order Rate Gyros	14 Nov 62	
30-024-D	Complete - Spacecraft Stabilization and Control System - Body Mounted Attitude Byros-Technical Design Specifications	14 Nov 62	
30-030-P	Complete - Spacecraft Stabilization and Control System - Procurement of ECA Components	14 Nov 62	
30-010-D	Complete - Spacecraft Stabilization and Control System - Preliminary Layout of Displays	30 Nov 62	
30-036-D	Complete - Spacecraft Stabilization and Control System - NAA Approval of Evaluators	1 Dec 62	

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Table 7. Apollo PMP Milestones

Stabilization and Control Subsystem (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
30-012-D	Complete - Spacecraft Stabilization and Control System - Parts Procurement for Manual Controls	14 Dec 62	
30-013-D	Complete - Spacecraft Stabilization and Control System - Fabricate Piece Parts for Manual Controls	14 Dec 62	
30-017-P	Complete - Spacecraft Stabilization and Control Subsystem - Order Accelerometer Package	14 Dec 62	
30-031-P	Complete - Spacecraft Stabilization and Control Subsystem - Fabrication of ECA Chassis	31 Dec 62	

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During the next report period, an integrated guidance control thrust vector control simulation will be carried out in which simulated MIT guidance equipment and the new MIT cross-product steering law will be incorporated.

SUBCONTRACTOR ACTIVITIES - MINNEAPOLIS-HONEYWELL

The completion of a new statement of work and revised procurement specifications for SCS continued into the report period. The new work statement, including the revised concepts of design criteria, documentation, qualification and review testing, and GSE was completed; a revised cost proposal will be prepared during the next report period.

In the new procurement specification, the firm allocation of cells and cell sizes has been transmitted to Minneapolis-Honeywell with the exception of the latching mechanism still in design.

As a result of the cost-reduction program, the SCS subcontractor effort has been subjected to major diversions of technical manpower, technical replanning, technical costing, and rescheduling. Among the major cancellations were the boilerplate SCS program, the horizon and sun sensors, the programmer sequencer, the lunar propulsion module effort, and the systems checkout GSE.

Evaluation testing of Marquardt reaction jet solenoid valves and Minneapolis-Honeywell driver circuitry will be continued during the next report period.

DESIGN STATUS

A complete SCS measurement list has been prepared which includes the requirements of the system for all the test points necessary for bench maintenance checkout, combined systems checkout, integrated systems checkout, in-flight test, and telemetry.

The relocation of electronic equipment in the lower equipment bay of the command module has been completed, with the SCS equipment in a more favorable in-flight maintenance position.

Initial design work on a simple service module engine-gimbaling servo-actuator test fixture has been completed. This laboratory device will be used in conjunction with the developmental evaluations of the electromechanical servo-actuator loops to determine the gains and shaping

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network required in actuator-driven electronics. This fixture will be capable of making parametric studies of amplitude, frequency, load, structural compliance, viscous damping, and spring rates in a single degree-of-freedom.

A scheme was defined for mechanizing the minimum-impulse buttons to be used in conjunction with the sextant navigational sightings. This mechanization uses the present pulse modulation technique and requires only the addition of a switch.

Circuits for the d-c amplifier, torquing amplifier, adjustable headband, and thrust vector control servo amplifier are undergoing breadboard development.

The preliminary rough draft of the SCS data manual covering coordinate systems, SCS components, and mode operations will be expanded, refined, and up-dated during the next report period.

The effects of nozzle-actuator-clutch time lag and the spring effects of the nozzle-actuator-clutch will be analyzed.

RELIABILITY STATUS

The electronic computer assembly (ECA) has been predicted to have a nonredundant failure rate of approximately 20 percent per 1000 hours. This indicates that ECA electronics will require some on-board spares to meet the reliability apportionment. Predictions for the reliability of controls and displays are being revised, based on the single-station concept.

The generic specifications for semiconductors, resistors, connectors, capacitors, and meter mechanisms have been reviewed. Some of these specifications have been approved by reliability for incorporation into the basic design of the SCS.

Table 8 lists the components of the predicted failure rates, mission times, reliability without redundancy (based upon Minuteman generic failure rates), reliability based upon the redundancies currently proposed (using Minuteman generic failure rates), reliabilities apportioned (using part-sensitivity indices as a basis for the apportionment), and the factors of criticalness (based upon the partial derivitive for the probability of crew safety with respect to the component). The value for the probability of crew safety used in the foregoing computation was derived from the mission phase logic diagrams.

The values of apportioned reliability are based upon alternate modes of operation. S&ID is presently conducting studies to determine the optimum

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Table 8. Stabilization And Control Subsystem

Equipment	$N\lambda° \; 10^{-6}$	Predicted Reliability		Proposed Redundancy	Apportioned Reliability	Criticalness Factor
		Time Hrs.	No Redundancy			
Flight director Attitude indicator	175.63	336	0.942730	0.996720	0.99755	0.084384
Gimbal positions indicator	15.65	336	0.994743	0.999972	0.99995	0.81119
SCS mode select panel	21.01	336	0.992941	0.999950	0.99935	0.96277
SCS adjust panel	51.02	336	0.983004	0.983004	0.99935	0.96277
*Delta V indicator	32.63	336	0.989033	0.994256	0.99715	0.008656
Body mounted attitude gyro	200.31	316	0.938704	0.938704	0.99869	0.020334
Electronic control assembly	364.83	336	0.884643	0.996798	0.99611	0.947096
Rate gyro package	150.19	316	0.953273	0.953273	0.99922	0.887310
Accelerometer package	50.01	336	0.984337	0.984337	0.999452	0.008554
Three-axis rotational control	31.11	61.8	0.998078	0.999996	0.99974	

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Table 8. Stabilization And Control Subsystem (Cont)

Equipment	$N\lambda° \; 10^{-6}$	Predicted Reliability		Proposed Redundancy	Apportioned Reliability	Criticalness Factor
		Time Hrs.	No Redundancy			
Translational control	25.61	61.8	0.998418	0.999998	0.99988	———
Display electronic package	———	———	———	———	0.99943	———
TOTAL	———	———	0.702914	0.850286	0.98600	———

*Redundant on the subassembly level

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number of spares for a range of electronic subsystem weights. The apportioned reliability will be achieved from the in-flight maintenance and spares concepts generated from these studies.

A study of gain requirements for the attitude reference system miniature integrated gyro (MIG) gyro-caging loop will be started, and the gyro mounting configuration will be completed.

The ECA packaging will be evaluated to reduce weight.

TEST STATUS

A reaction jet, fluid test bench has been completed. This device permits water loading of the reaction jet solenoid valves, similar to those conditions which will exist in flight with fuel and oxidizer loads. Preliminary tests of the Marquardt three-coil solenoid valve have begun, with the objective of determining pull-in and drop-out times, current time-histories, and the compatibility between valves and driver circuitry. A minimum drop-out time of 8 milliseconds has been achieved.

The body-mounted attitude gyros will be mounted on a structure containing integral cooling to maintain the proper operating temperature environment for these gyros. A proportional temperature control amplifier has been breadboarded, and initial tests on this device have been favorable.

The flight-director attitude indicator has been subjected to vibration scans, and the need for stiffer meter bracketry requirements was disclosed. Performance checks with this device at both high and low temperatues were completed with satisfactory results.

The detailed design of a thrust vector control servo-actuator test fixture will be completed.

The first cuts of the SCS navigation and guidance functional diagrams are expected to be complete during the next report period.

Reliability studies to determine the necessity for higher reliability components, redundancy, or failure detection will be continued. Specific failure detection schemes, such as rate gyro failures, are also under evaluation.

Alternate mechanizations of the attitude gyro coupler unit will be evaluated for purposes of simplification.

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LAUNCH ESCAPE SUBSYSTEM

Milestones completed during November and those scheduled for December are shown in Table 9.

FABRICATION

Escape Tower

The 11 mill fixture tools required for the new launch escape tower configuration were completed during the report period. These tools were completed on a special project basis in order to support effective design change on the second tower structure for static tests.

Buna rubber will be used for insulation of the tower structure from the blast of the rocket motor. This insulation material will be wrapped and bonded to the tubing on all towers scheduled for dynamic tests. Present schedules do not allow for this new process, and so an investigation is under way to determine schedule impact. Assembly operations on both the static and dynamic test configurations will receive emphasis during the next report period. Concentrated effort will be made on the major assembly tooling required for the new configuration.

REQUIREMENTS AND ANALYSIS

Engine Analysis

The launch escape motor thrust vector computer program was used to calculate the effect of altitude and axisymmetric erosion of thrust vector variation.

During the next period, test firings will be observed and an analysis of test data will be performed.

Plume Analysis

Revision of the launch escape system (LES) tower configuration has caused a reexamination of the plume impingement problem. A method of extrapolating solutions from known methods of characteristics has been

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Table 9. Apollo PMP Milestones

Launch Escape Subsystem

Event No.	Milestone Description	Date	
		Schedule	Actual
32-010-D	Start - Fabrication of First Launch Escape System Static Test Tower	2 Nov 62	2 Nov 62
32-027-D	Complete - Pyrogen Test for Tower Jettison Motor - Thiokol	8 Nov 62	
32-058-P	Complete - Delivery Tower Jettison Motor (Inert, Non-Fireable) Boilerplate 9	9 Nov 62	1 Oct 62
32-071-P	Complete - Delivery Launch Escape Motor (Inert, Non-Fireable) Boilerplate 9	16 Nov 62	12 Oct 62
32-011-D	Start - Launch Escape Development Motor Tests - Lockheed	29 Nov 62	
32-027-D	Complete - Pyrogen Test for Tower Jettison Motor - Thiokol	30 Nov 62	
32-026-D	Complete - Program Test for Launch Escape Motor - Lockheed	10 Dec 62	
32-012-D	Start - Pitch Development Motor Test - Lockheed	21 Dec 62	
32-039-P	Complete - Manufacturing Launch Escape Tower Boilerplate 9	28 Dec 62	

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initiated to verify use of the holographic methods now being used to determine the characteristics of the LES motor plume.

The fire-in-the-hole analysis for stage separation between the Saturn-IV, service module, and lunar excursion module will be continued during the next period.

Particle distribution in the LES exhaust plume will be investigated.

DESIGN STATUS

Apollo Test Requirements

Detail drawings for launch escape attachment fittings test programs have been completed.

Escape Tower

The launch escape tower insulation installation drawing was released.

Design studies of the internal structure of the LES tower configuration continued with concentration on developing a tubular ring and a welding material to join the ring and diagonal members.

Sample joints of the ring material (A55 commercially pure titanium) and the diagonal material (6Al 4Va titanium) formed with 6Al 4Va titanium welding material are being tested for strength.

The A55 commercially pure titanium ring has a safety margin of approximately ten percent. A tubular rectangle is being considered as a back-up. This design yields a much higher safety margin.

During the next period, work will continue on drawing revisions to incorporate wire routing and access provisions in the flow separator and structural skirt assemblies.

A control layout establishing installation provisions for the various components of the electrical system will be prepared.

Work will continue on the design layout to provide forward head shield jettison attenuation during abort modes.

Rocket Motors

Revised drawings of the pitch control motor support assembly, including electrical access and motor mounting provisions, have been released.

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The LES rocket motor installation drawings have been revised to include the pitch control motor and the latest end item subassembly assignments.

SUBCONTRACTOR ACTIVITIES — THIOKOL CHEMICAL COMPANY

Processing and casting problems were discovered with the pouring of the first batch of development motors. Analysis of the faulty castings and study of improved castings will be made during December with new techniques and more rigid controls.

RELIABILITY STATUS

A failure mode analysis of the three solid rocket motors has been completed, based on the final design before development testing.

Apportionment studies of the LES for both the abort mode and tower jettison mode are continuing.

Initial delivery of exploding bridge wire (EBW) initiators with a reliability of 0.90 at 0.80 confidence level has been made. Development data on the initiators will be maintained and utilized for further reliability assessment.

During the next period, a reliability analysis of the tower release mechanism will be conducted to determine to what extent reliability would be improved by the addition of a redundant release mechanism.

Development test procedures for the solid rocket motors will be reviewed.

SUBCONTRACTOR ACTIVITIES — LOCKHEED PROPULSION COMPANY

Lockheed Propulsion Company successfully cast the propellant for the first live motor. The test firing of this motor is scheduled.

TEST STATUS

<u>Ground Tests</u>

Several trial launch escape motor propellant batches were cast to check casting procedures prior to the casting of the first live motors. Six pyrogen units were cast from these propellant batches. Two were successfully static fired, using hot wire squibs. All future firings will be conducted with EBW squibs.

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The inert tower jettison motor, the inert pitch control motor, and the inert tower jettison motor for boilerplate 9 were received.

Two tower jettison motors were successfully cast by a bottom-up method in which the propellant was fed through the core of the mandrel to the bottom (head end) of the case and then forced upward.

Tests of the General Laboratory Associates EBW units were completed.

The launch escape sequencing system has been completed and demonstrated successfully.

Materials

PH15-7 Mo steel welded tubing was subjected to longitudinal tensile and compression tests. Butt-welded joints also were tensile tested. All test results were within minimum specification requirements.

The manufacture of titanium 6A1-4V welded structural tubing has been accomplished successfully.

Welding of a K cluster of Ti-6A1-4V tubing has been accomplished by using local argon shielding, bagging techniques, and welding parameters. This cluster will be tested to determine longitudinal properties.

Brazed Honeycomb Sandwich

The testing of Rene 41 honeycomb panels at elevated temperatures proceeded in conjunction with brazed honeycomb sample reliability testing at 1800 to 2000 F. The bonds of both structures have been check tested and are undergoing photographic lab analysis. The panels will be sectioned into smaller test samples in preparation for mechanical tests.

Maraging Steel

The plan of action for verification of process specifications is being reevaluated to assure that all processing parameters are adequately covered. Material for a program to develop design allowables for maraging steel (18Ni-9C0-5Mo) has been ordered.

ENVIRONMENTAL CONTROL SUBSYSTEM

REQUIREMENTS AND ANALYSIS

Milestones completed during November and those scheduled for December are shown in Table 10.

Coolant System

Cabin Atmosphere Contamination

The maximum average safe level of atmospheric contamination by ethylene glycol is estimated to be 254 milligrams per cubic meter. Leakage and quick-disconnect spillage must be controlled below this contamination level.

Interface Material

A sample of thermal interface material (thermal fuzz) was tested for conductance and deflection. This sample exceeded the required conductance value by 30 percent. The conductance did not vary from atmospheric pressure operation to operation in a vacuum at 1×10^{-4} millimeters of mercury.

Coldplate Fabrication

The feasibility of coldplate fabrication by electron-beam welding is being investigated.

Cryogenic Storage System

S&ID has established that 640 pounds of usable oxygen and 56 pounds of usable hydrogen are required for a 14-day mission. These quantities are sufficient under single-tank operation for return from any point in the mission profile.

A preliminary investigation indicates that a grid pattern in the cryogenic tank and support structure material is not necessary. This significantly reduces tank fabrication cost.

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Table 10. Apollo PMP Milestones

Environmental Control Subsystem

Event No.	Milestone Description	Date Schedule	Date Actual
33-061-D	Complete - Boilerplate ECS Special System Component Tests	1 Nov 62	
33-020-D	Complete - Preliminary Breadboard Coldplate Design Release	6 Nov 62	
33-031-D	Complete - Fabricate Space Radiator Breadboard Test	12 Nov 62	
33-069-D	Complete - Fabrication and Assembly Development ESC/GSE	12 Nov 62	
33-008-D	Complete - ECS 100 Percent Design Release for Boilerplates	14 Nov 62	
33-021-D	Complete - Coldplate Breadboard Tests	15 Nov 62	
33-070-D	Complete - ECS Component Test With GSE Component Test Stand Development GSE	16 Nov 62	
33-071-D	Complete - Subsystem Development With Console Development ESC/GSE	22 Nov 62	
33-022-D	Complete - 100 Percent Coldplate Design Release	23 Nov 62	
33-032-D	Complete - 100 Percent Space Radiator Design Release	23 Nov 62	
33-072-D	Complete - 100 Percent Drawing Release Production ESC/GSE	23 Nov 62	

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Table 10. Apollo PMP Milestones

Environmental Control Subsystem (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
33-023-D	Complete - Coldplate Design Verification Tests	15 Dec 62	
33-024-P	Complete - Coldplate Fabrication and Assembly	15 Dec 62	
33-063-P	Complete - Boilerplate ECS Water Tank Delivery Boilerplate 12	15 Dec 62	
33-009-P	Complete - Fabrication and Assembly of Qualified Production Boilerplate ECS	20 Dec 62	
33-025-P	Complete - Coldplate Qualification Tests	31 Dec 62	
33-026-P	Complete - Coldplate Reliability Analysis	31 Dec 62	

Electron-beam welding without stress relief will be used for fabrication of the internal electrical heaters because these units cannot withstand relatively high temperatures after they are welded.

The procurement specification for this system has been revised to include the latest oxygen and hydrogen requirements.

Instrumentation and Checkout

At least 27 measurements will be required for system performance characteristics: 15 for the environmental control system and 12 for the cryogenic storage system.

Studies concerning the hazards, necessity, and alternate methods of checking out the cryogenic storage system as integrated with the environmental control subsystem (ECS) and electrical power systems at AMR vacuum facilities are being conducted at the request of NASA.

During the next report period, ECS in-flight maintenance requirements will be established. A committee will document an in-flight maintenance concept for presentation to NASA.

The ECS checkout procedure for AMR will be completed.

Documentation

Specifications

S&ID and Beech Aircraft reviewed and revised the cryogenic storage system specification.

General requirements for simulators 1 and 2 have been received; preliminary data have been prepared for equipment specifications.

During the next report period, design layouts, installation, and detail drawings will be prepared for special environmental equipment for simulators 1 and 2.

Test Plans

A detailed test plan for space radiators is approximately 40 percent complete.

SUBCONTRACTOR ACTIVITIES — AIRESEARCH

Every component necessary for conducting prototype testing is in the manufacturing cycle. Breadboard testing on the major glycol subsystem has been completed.

Documentation

A preliminary copy of Revision 4 of the AiResearch system specification was reviewed and commented on.

AiResearch motion picture documentation was reviewed to evaluate its use by engineering. The documentation was returned with comments.

Technical Activity

AiResearch presented a complete rundown on the technical status of the system's hardware utilization, schedules, cost information, and various other facets of ECS and ECS-GSE projects. AiResearch will advise S&ID if provisions for measuring the power input to motor-driven components will be required.

S&ID advised AirResearch that it would be responsible for wiring to individual components and packages, and that AiResearch is to provide only the internal wiring of the packages. Switches will be the responsibility of S&ID.

AiResearch was notified of the ECS-waste management system interface requirements concerning the gaseous wastes entering the pressure suit circuit.

DESIGN STATUS

Coolant System

Water-Glycol Circuit

A layout of the water-glycol line routing from service to command modules has been prepared. Line diameters have been established.

The water-glycol loop in the service module has been revised in accordance with the recent establishment of the space radiator locations. The radiator valve package has been moved into the fairing area between service and command modules for easier access.

The glycol fill-and-vent connections were relocated from within to the outer skin of the service module.

Coldplates

S&ID has prepared a counter proposal to the MIT design requirement which calls for coolant circulation within the walls of the sextant/telescope unit. As presently designed, the coolant loop would be broken if the sextant/telescope were repaired or replaced. The S&ID proposal calls for cooling the sextant/telescope assembly with a coldplate. A layout of the proposal has been prepared.

A study to evolve a configuration for a coldplate in the service module for fuel-cell power and overload relay mounting is being conducted.

A design for a side-clamping mechanism for electronic boxes is under consideration.

Seven more coldplates will be added in the right-hand electrical equipment bay.

During the next period, design of the coldplates for the command module battery, command module inverter, and service module signal conditioner will be completed.

Design of the coldplates for the fuel-cell relay will begin.

Space Radiators

The ECS space radiators have been relocated to accommodate provisions for on-pad access to the electrical power subsystem (EPS) fuel cells. The two access panels now overlap sextants II and III and sextants V and VI.

A layout showing alternate cooling passages in a single panel is being prepared. This routing will have an effective total panel area dependent on mission requirements.

Testing of the space radiator panels will begin during the next period.

<u>Pressure Suit Circuit</u>

Suit circuit layouts in the right-hand and upper equipment bays are being modified to comply with center of gravity relocation and seat attenuation changes.

Cabin Pressure and Temperature Control

The equipment in the left-hand forward equipment bay is being regrouped to provide more accessible locations for the pressure suit disconnect and an improved packaging concept of the cabin heat exchanger. Relocation of the pressure suit disconnect from the aft to the inboard web greatly improves visibility and accessibility.

The water-glycol valves are being consolidated to reduce the package and number of connections. Heat exchanger, louvers, and valves are being installed as an integrated package.

For minimum design change to the cabin pressure relief valve, and for weight and reliability, the original pressure differential valve will be retained. This valve will vent through the steam vent duct, but will incorporate an ambient sensing port in the annulus between the inner and outer structure.

A ΔP of 6 psia across the inner shell can be maintained during transient pressure conditions.

The steam vent duct is being redesigned to reduce the pressure drop.

Water Management

An exit location for the evaporator vent duct has been established. However, as the present location causes excessive pressure drop, the feasibility of reducing the pressure drop by straightening out the routing and/or slightly increasing the duct diameter is being studied. Routing the duct through the heat shield perpendicular to the command module skin is also being considered.

A water shutoff valve was added to the potable water tank supply line to isolate the tank in case of fuel cell water contamination. A relief line and check valve were added to prevent fuel cell water from bypassing the water tank pressure relief valve and entering the waste water circuit. A water quick-disconnect also was added between the command module and service module.

Waste Management

The control panel and the urine and chemical tanks have been relocated in the right-hand equipment bay. The fecal canister has been relocated in the crew area aft equipment bay. Components are being repackaged to fit in the allotted area.

The food storage compartment has been moved from the upper bay to the crew area aft equipment bay.

The panel width was reduced from 6 inches to 5.75 inches.

The compartment ventilation system layout is being revised because of the relocation of the storage compartments in the right-hand equipment bay.

The urine overboard line will be rerouted and connected to the steam vent line. It was decided that the superinsulation of the aft equipment bay would be rendered ineffective if urine were dumped there.

Cryogenic Storage Subsystem

The design concept of the quantity balance control has been established. It embodies the principle that an equal amount of heat will expel and equal amount of fuel. This concept involves an electronic circuit that initiates heater operation in both tanks simultaneously when either reaches the lower limit for pressure control. The circuit then allows both tanks to build up pressure independently to the upper limit for control.

S&ID determined that vibratory loads rather than acoustics are a design factor in the grid pattern of the outer tank shell because of the flexible service module structure on which the tanks will be mounted. Maximum vibration will occur at maximum dynamic pressures during launch.

Investigations are being conducted to determine if the vibration testing can be performed with an ambient pressure corresponding to the altitude where maximum dynamic pressure occurs.

A new system arrangement is being prepared showing a slight shift in the storage tank position. This arrangement permits a shortening of the support skirts on the oxygen tanks and a weight saving of 8 pounds.

Packaging

Cost and weight reduction and center-of-gravity relocation program have considerably changed the ECS package in the left-hand equipment bay. A layout of the latest configuration is being reviewed.

The increased travel of crew couches necessitated increasing the size of the side attenuation panel so that it covers the present location of the Carbon dioxide absorber canisters. The only remaining area for the canisters is above the side attenuation panel, where accessibility is limited. Considerable redesign of ducting, manifolds, and components will be necessary to relocate the canisters.

Mock-ups

The ECS mockup installation drawing releases for the service module were edited for the latest design criteria requirements. Extensive cryogenic storage and water-glycol systems revisions were completed.

Installation of components and routing of the cryogenic lines in the service module are in process. The latest installation of the waste management controls unit conforming to the structurally-revised right-hand equipment bay in the command module has been released.

RELIABILITY STATUS

The ECS qualification-reliability program is being revised in accordance with the new testing concept.

TEST STATUS

Boilerplates

The cooling subsystem for boilerplate 12 has been firmed, and the required coldplates have been detailed.

The revised schematic drawing of the water-cooling subsystem for boilerplate 12 is complete. The locations of the two telemeter units and the two C-Band transponders have been established. The telemeter and C-Band transponder locations for boilerplate 13 and 15 have been established.

The coolant flow in boilerplates 13 and 15 has been changed from parallel to series. This change does not affect detailing of parts available off-the-shelf valves, pump, and motor can be used in these boilerplates. The same pump will be used for boilerplate 12.

Layouts for prototype ECS equipment installation in boilerplate 14 will be prepared during the next period.

Design layouts will be completed for boilerplate 14 and the spacecraft showing the pressure suit circuit in the left-hand equipment bay and left-hand forward compartment. Details will be prepared for production release.

Airframes

A summary of ECS test requirements for airframe 8 has been prepared. These requirements supplement the airframe 8 environmental proof test program. The ECS preparation test requirements for airframe 1 also have been prepared.

ECS Breadboard

The preliminary ECS breadboard test has been prepared, and techniques to simulate the various conditions to be encountered during the Apollo mission are being completed.

Bench Testing

The first 1/2-inch adhesive-bonded coldplate fabricated for thermal testing was pressure cycled. It withstood 20 cycles at proof pressure (90 psig). Pressurizing to failure resulted in a leak at 200 psig.

A test is being prepared to determine the effect of an uninsulated fill line on a filled liquid nitrogen Dewar tank.

During the next period, cryogenic storage system development tests, including cycling and burst tests at ambient as well as cryogenic temperatures, will be performed on the 17-inch development pressure vessels. The vessels are electron-beam welded, nonstress relieved.

An ECS hardware exhibit will be prepared for the NASA engineering development inspection scheduled for December.

Coldplates

A preliminary detail test plan for a coldplate network is near completion. Four test coldplates have been ordered: two with aluminum and two with Fiberglas honeycomb cores. A thermal interface material composed of an elastomer with silver as a filler is being tested. Tests using silver particles suspended in a calking compound for interface material were unsuccessful because the heat conductance characteristics were too low. Detailed test data are being compiled.

Adhesive Bondings

An adhesive bonding test for insulation has been initiated to support boilerplate 13.

Connectors

Fabrication of fill connectors for cryogenic test purposes is complete, and the test procedure is in progress.

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Temperature Control Coatings

An investigation of temperature control coatings on previous space probes is being conducted to determine what effects meteorite bombardment and other space environmental conditions had on the coatings used.

Space Radiator

Two samples of 7075 aluminum sheet that were resistance-welded with tube passages are being joint-tested and analyzed for alloy identification. A design sketch shows a strip and preformed sheet configuration.

Couplings

A test report for two 1/2-inch On Mark couplings indicates that the pull angles were varied from 0 degree (direct pull) to 30 degrees with internal test pressures at 0 and 30 psig. The maximum uncoupling force was 4.5 pounds, the minimum force 1 pound.

Two quick disconnect couplings also are being performance-tested.

Fittings

The mechanical fittings recommended for use on cryogenic storage system components are MC or Del copper crush wasters. These fittings promote sealing and expansion of tubes to fit sleeves thus increasing their strength. The recommendations are preliminary, pending completion of the existing test program.

EARTH LANDING SUBSYSTEM

REQUIREMENTS AND ANALYSIS

The milestones completed during November and those planned for December are depicted in Table 11.

The parachute drop test program was presented and approved by NASA in the regular mechanical system design review meeting.

A revised version of the parachute subsystem procurement specification was completed.

The drogue parachute attachment geometry was investigated; a change from the single point attachment is being considered. Improvement command module dynamic stability is obtained with a four-line bridle.

An analysis of the present command module static and dynamic characteristics substantiated the unfavorable apex-forward flight performance test. Terminal velocities of the 9500-pound command module in apex-forward flight exceed the drogue parachute design envelope. Also, the apex cover cannot be jettisoned under all conditions in apex-forward flight. Drogue parachute deployment from apex-forward flight at terminal dynamic pressures produces unfavorable transient conditions for main parachute deployment during low-altitude aborts. The analysis of drogue command module dynamics is being revised to incorporate refinements in the equations of motion.

SUBCONTRACTOR ACTIVITIES — NORTHROP-VENTURA

The weighted bomb drop test series continued during the period with 15 tests completed. The testing of cluster parachutes will continue through December.

DESIGN STATUS

A firm envelope outline for the drogue and pilot mortars was established. A design study layout of the baroswitch static pressure pick-up locations was completed.

The studies of parachute disconnect methods produced tentative designs for both the main and drogue parachute release mechanisms.

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Table 11. Apollo PMP Milestones

Earth Landing Subsystem

Event No.	Milestone Description	Date Schedule	Date Actual
34-020-D	Complete - Design and Development Drogue-Chute System (4 Tests)	27 Oct 62	21 Nov 62
34-028-D	Complete - Sequence Control Design - Recovery System	30 Oct 62	9 Nov 62
34-009-D	Start - Single Chute Development Testing	1 Nov 62	
34-023-D	Start - Drogue Wind Tunnel Tests	15 Nov 62	15 Nov 62
34-021-D	Start - Drogue Development and Design Verification Tests	18 Nov 62	
34-010-D	Complete - Single Manchute Development Testing - 11 Tests	4 Dec 62	
34-011-D	Start - Single Manchute Design Verification	5 Dec 62	
34-005-P	Complete - Boilerplate 13 Command Module Delivery To Northrup-Ventura	8 Dec 62	
34-021-D	Start - Drogue Development and Design Verification Tests	14 Dec 62	
34-032-D	Complete - Design Location Aids	14 Dec 62	
34-047-P	Complete - Delivery Escape Launch Subsystem - Less Pyro and Chutes - Pre-Qualified Boilerplate 6	15 Dec 62	

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Table 11. Apollo PMP Milestones

Earth Landing Subsystem (Cont)

Event No.	Milestone Description	Date Schedule	Date Actual
34-051-P	Complete - Delivery Escape Launch Subsystem - Less Pyro And Chutes - Pre-Qualified Boilerplate 23	18 Dec 62	

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During the next period, studies will be conducted on ejection systems which would be capable of forward compartment heat shield removal without the use of the tower.

Studies will be conducted to develop release mechanisms for the forward compartment heat shield that will not incorporate the use of cables.

Final design of the sequence controller will be accomplished.

A drogue parachute attachment geometry will be recommended, the command module dynamics will be investigated further, and earth landing system sequences will be optimized to reduce recovery complexity.

RELIABILITY STATUS

Earth Landing Sequencer

A reliability evaluation was made of crossover versus non-crossover for the wiring of the earth landing sequencer. It was found that crossover wiring increases system reliability slightly, but the added complexity in assembly and possible weight increase does not warrant its use.

Forward Heat Shield Release Systems

A reliability evaluation was made of four forward heat shield release systems. Three of the systems use a toggle release mechanism with different means of activating the four thrusters. The remaining system is a sliding collet-type latch release. The toggle release mechanism, which uses a gas generator for generating power for the thrusters, was found to be the most reliable of the four.

TEST STATUS

Boilerplates and Major Tests

Parachute Drop Tests

Drop test 9 was conducted using an 88.1-foot diameter ringsail main canopy. Deployment was made at 100-psf dynamic pressure to prove the parachute could withstand 1.5 times the design dynamic pressure (64 psf). The pilot chute bridle failed. Also the pilot chute separated completely. The main canopy inflation and descent was normal with only minor damage.

Drop test 10 was conducted to determine the structural integrity of an 88.1-foot diameter, lightweight, single main parachute at 1.5 times the design dynamic pressure. The reefing line failed, resulting in very high loads and a rupture of the canopy. There was no initial damage in the crown.

Drop test 11 was conducted to further test the strength of the lightweight canopy. Tested at 1.5 times the design dynamic pressure, the parachute was torn along one main seam. This result demonstrated that the heavier canopy (as used in Test 9) is required to withstand this ultimate condition.

Drop test 12 was conducted to investigate the strength of the single main canopy deployed at speeds over the 1.5 condition. The chute main seam failed after full inflation, but the descent and terminal velocity was normal. Results of the test were satisfactory.

Wind Tunnel Test Program

Several scale-model drogue parachutes were tested in a low-speed wing tunnel. Good agreement between model and full-size drogue drag coefficients was obtained.

Boilerplates

Boilerplate 3 is 95-percent complete. Boilerplate 19 is 82-percent complete.

Materials

Tests were conducted to determine the effects of fuels (Aerozine 50 and nitrogen tetroxide) on parachute materials. The deleterious effect of the nitrogen tetroxide or its vapor on the parachute indicated that measures must be employed to prevent contact of nitrogen tetroxide with the parachute material. The effect of aerozine 50 on the parachute material caused a slight change in appearance and loss in tensile strength.

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COMMUNICATIONS SUBSYSTEM

REQUIREMENTS AND ANALYSIS

Milestones completed during November and those scheduled for December are shown in Table 12.

Specifications

S&ID has prepared individual equipment specifications for all the equipment in the communications and data subsystem.

Radio Frequency Electronics

DSIF Transponder

Circuit margin charts are being revised as the result of several conferences with the subcontractor that clarified deep space instrumentation facility (DSIF) requirements.

As a result of a presentation to NASA that detailed the communications requirements of Apollo, S&ID will proceed with the present design approach.

A review of the DSIF radio-frequency power required to support communications reconfirmed the fact that a 20-watt output is necessary. This review was caused by the possibility of reducing the output power to permit the use of the existing traveling wave tubes.

C-Band Transponder

A clarification of the equipment requirements has been made. The revised specification requires that both signal comparison and antenna selection be done on a pulse-to-pulse basis. This is done to insure satisfactory operation with chain radars and to alleviate tracking hand-over problems.

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Table 12. Apollo PMP Milestones

Communications Subsystem

Event No.	Milestone Description	Date	
		Schedule	Actual
35-001-D	Complete - Preliminary Systems Specifications & Design Criteria VHF/FM Transmitter	1 Nov 62	
35-002-D	Complete - Equipment Specifications Approval VHF/FM Transmitter	1 Nov 62	
35-003-D	Complete - Preliminary Design VHF/FM Transmitter	1 Nov 62	
35-006-D	Complete - Equipment Specifications Approval VHF/AM Transceiver	1 Nov 62	
35-009-D	Complete - Equipment Specifications Approval Deep Space Instrumentation Facility Transponder	1 Nov 62	
35-013-D	Complete - Equipment Specifications Approval Deep Space Instrumentation Facility Power Amplifier	1 Nov 62	
35-016-D	Complete - Equipment Specifications Approval Very High Frequency Recovery Beacon	1 Nov 62	
35-021-D	Complete - Equipment Specifications Approval High Frequency Transceiver	1 Nov 62	
35-022-D	Complete - Preliminary Design High Frequency Transceiver	1 Nov 62	
35-025-D	Complete - Equipment Specifications Approval C-Band Transponder	1 Nov 62	

Table 12. Apollo PMP Milestones

Communications Subsystem (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
35-030-D	Complete - Equipment Specifications Approval Television	1 Nov 62	
35-035-D	Complete - Equipment Specifications Approval Telemetry Equipment	1 Nov 62	19 Nov 62
35-040-D	Complete - Equipment Specifications Approval Signal Conditioner	1 Nov 62	
35-041-D	Complete - Preliminary Design Signal Conditioner	1 Nov 62	
35-044-D	Complete - Equipment Specifications Approval Data Patch Panel	1 Nov 62	
35-045-D	Complete - Preliminary Design Data Patch Panel	1 Nov 62	
35-048-D	Complete - Equipment Specifications Approval Intercommunications	1 Nov 62	
35-051-D	Complete - Equipment Specifications Approval Controls and Displays	1 Nov 62	
35-052-D	Complete - Preliminary Design Controls and Displays	1 Nov 62	
35-055-D	Complete - Equipment Specifications Approval 2KMC Omni-Antenna	1 Nov 62	

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Table 12. Apollo PMP Milestones

Communications Subsystem (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
35-056-D	Complete - Preliminary Design 2KMC Omni-Antenna	1 Nov 62	
35-058-D	Complete - Component Specifications Approval Non-Reentry Radome	1 Nov 62	1 Nov 62
35-059-D	Complete - Subcontractor Selection Approval Non-Reentry Radome	1 Nov 62	
35-067-D	Complete - Equipment Specifications Approval Backup Very High Frequency Recovery Antenna	1 Nov 62	1 Nov 62
35-069-D	Complete - Equipment Specifications Approval Reentry Telemetering Radome	1 Nov 62	
35-071-D	Complete - Equipment Specifications Approval C-Band Antenna	1 Nov 62	
35-072-D	Complete - Preliminary Design C-Band Antenna	1 Nov 62	
35-010-D	Complete - Subcontractor Selection Approval Deep Space Instrumentation Facility Transponder	15 Nov 62	9 Nov 62
35-017-D	Complete - Subcontractor Selection Approval Very High Frequency Recovery Beacon	15 Nov 62	

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Table 12. Apollo PMP Milestones

Communications Subsystem (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
35-018-D	Complete - Preliminary Design Very High Frequency Recovery Beacon	15 Nov 62	
35-026-D	Complete - Subcontractor Selection Approval C-Band Transponder	15 Nov 62	
35-027-D	Complete - Preliminary Design C-Band Transponder	15 Nov 62	
35-074-D	Complete - Equipment Specifications 2KMC High Gain Antenna	15 Nov 62	
35-036-D	Complete - Subcontractor Selection Approval Telemetry Equipment	15 Dec 62	
35-037-D	Complete - Preliminary Design Telemetry Equipment	15 Dec 62	29 Nov 62

Radio Recovery Aids

The modulation technique and power output of the high frequency/ transceiver was reviewed. As a result of the propagation studies and equipment design revisions incurred through redirection of the original SSB to AM equipment, S&ID recommends the adoption of compatible AM/SSB high-frequency equipment. The flexibility of this equipment will best fulfill the Apollo requirements.

Data Systems

Central Timing Equipment

Proposals for the central timing equipment are being evaluated.

An evaluation of the proposals for central timing equipment will be completed during the next report period.

Telemetry Equipment

Proposals for the pulse code modulation (PCM) telemetry equipment have been evaluated.

TV Equipment

Television camera locations in the command module have been determined.

Antennas

Beacon

The present R&D beacon configuration employs four antennas mounted circumferentially on the command module.

A recent heat protection requirement for boilerplate 13 employs a 5/32-inch layer of cork material on the exterior of the command module. A pattern-range investigation is under way to determine what explicit effects cork may have on the radiation patterns. If significant deviations are measured, further consideration will be given to mounting the antennas on the service module.

During the next report period, a subcontractor will be selected for the recovery antenna.

An investigation will be made to determine if existing boilerplate or airframe test articles can be used to take full-scale antenna patterns.

Radome

S&ID decided that the radome will be designed to a thin-wall construction, rather than to a half-wall construction.

Revisions to the specification are being made in the areas of thermal profile data, stress loads, and reliability test requirements.

The radome procurement specification will be released during the next report period.

VHF Omniequipment

Preparations are in progress to procure a Rantec filter for boilerplate 13. NASA has been requested to confirm the filtering requirements. In the absence of explicit requirements, filter characteristics will be similar to those for the component designed for laboratory studies by NASA.

C-Band Transponder

New station locations for the operational C-band transponder antennas on the command module have been determined. The antennas were relocated to avoid pattern distortions caused by window covers and to reduce coaxial cable weight. Four antennas are located 90 degrees apart (three at Station 28 and one at Station 62, near the plus Z axis).

The new antenna locations and desired performance characteristics are being incorporated in the procurement specification.

SUBCONTRACTOR ACTIVITIES - COLLINS RADIO COMPANY

Design and development efforts for the Apollo communications subsystem continued through November. Motorola Corporation has been selected as the subcontractor for the DSIF transponder, and Leach Corporation has been selected as the subcontractor for the data storage system. The selection and screening of additional subcontractors for various portions of the communications subsystem will continue and additional awards are expected to be let during the next report period.

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Collins Radio Corporation will deliver the research and development VHF omniantenna equipment for boilerplate 12 by 15 January 1963, and for boilerplate 13 by 15 February 1963.

RELIABILITY STATUS

Table 13 lists the predicted reliability of components of the communication subsystem.

The predicted reliability without redundancy factor is based on Minuteman generic failure rates. These data are also used for the prediction of reliability with proposed redundancies.

The apportioned reliabilities use part-sensitivity indices as a basis for the apportionment. The values of apportioned reliability are based on alternate modes of operation. S&ID is conducting studies to determine the optimum number of spares for a range of electronic subsystem weights. In-flight maintenance and spares concepts generated from these studies will establish the apportioned reliability.

The factors of criticalness are based on the partial derivitive for the probability of crew safety with respect to the component. The value for the probability of crew safety used in the foregoing computation was derived from the mission phase logic diagrams.

GOSS

Work proceeded on the study of signal strengths, available from the spacecraft to the GOSS remote sites, as related to range and spacecraft orientation for various trajectories.

Information is being gathered on current GOSS stations and on the station modifications planned for the Apollo program.

The final draft of the work statement for the Apollo spacecraft reflectivity study has been prepared.

The space communications and testing laboratory schedule has been revised and costs further reduced. This facility will be used to verify the compatibility of spacecraft techniques and equipment with the ground environment.

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TABLE 13. COMMUNICATION AND DATA SUBSYSTEM
(November 1962)

Equipment	$H\lambda° \; 10^{-6}$	Time Hrs.	Predicted Reliability		Apportioned Reliability	Criticalness Factor
			No Redundancy	Proposed Redundancy		
VHF recovery beacon	4.136	72.3	0.999701	0.999701	0.999995	0.000000183
HF transceiver	13.427	7.5	0.999899	0.999899	0.999992	0.000000086
VHF/AM transceiver	23.734	29.3	0.999305	0.999999	0.999954	0.021560
VHF/FM transmitter	12.362	5.3	0.999939	0.999939	0.999972	—
Audio center	12.189	408.4	0.995022	0.996678	0.999449	0.021563
Data storage	18.949	84.1	0.998406	0.998406	0.999944	0
C-band transponder	21.255	9.7	0.999794	0.999794	0.999939	0.021544
DSIF transponder	83.922	268.1	0.977752	0.999906	0.998686	—
DSIF power amplifier	22.274	117.8	0.997376	0.999994	0.009756	0.047903
Controls and Displays	64.245	336.4	0.978619	0.978619	0.999300	—
Premodulation processor	53.831	335.9	0.982081	0.982081	(0.999592)*	—
Signal conditioner	8.377	335.9	0.997186	0.997186	(0.999739)*	—

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TABLE 13. COMMUNICATION AND DATA SUBSYSTEM (Cont)
(November 1962)

Equipment	$H\lambda° \, 10^{-6}$	Time Hrs.	Predicted Reliability		Apportioned Reliability	Criticalness Factor
			No Redundancy	Proposed Redundancy		
PCM telemetry	369.387	335.9	0.883308	0.883308	0.998102	
Analog-to-digital converter	2.94	335.9	—	—	—	—
Power supply	5.70	335.9	—	—	—	—
Programmer, generator and modulator	8.08	335.9	—	—	—	—
Time base	38.096	335.9	—	—	—	—
Digital commutator	32.832	335.9	—	—	—	—
Analog commutator	94.58	335.9	—	—	—	—
VHF/2KMC omni-antenna	—	273.1	0.999757	0.999757	0.999999	0.021630 —
TOTAL			0.818577	0.841303	(0.994419) .995088	

*Added to equipment list after apportionment

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COMMAND MODULE STRUCTURE AND SUBSYSTEM INSTALLATION

Milestones completed during November and those scheduled for December are shown in Table 14.

FABRICATION

Boilerplate activity was highlighted during the report period by NASA acceptance of boilerplate 19 (command module structure). This command module, now undergoing installation operations, is scheduled for completion on 21 December. Boilerplate 6 (command module) structure continued to progress toward anticipated schedule recovery by 15 February 1963. Boilerplates 9 and 12 are currently three to four weeks behind schedule, but schedule recovery is anticipated by 1 January 1963 and 12 April 1963 respectively. Boilerplate 2 (command module) was accepted by NASA, bringing this boilerplate to a three week behind schedule condition as it enters the final installation and checkout operation.

Boilerplate 3 (command module) is progressing on schedule through final installation and checkout operations. This boilerplate is scheduled for presentation to NASA with certain forward compartment shortages. It will then be shipped to Northrop-Ventura, where the equipment will be installed.

Approval has been received for the design and fabrication of two additional boilerplate command modules to be used in Apollo simulation complexes. These command modules will be of the same basic design as house spacecraft 1, except that systems requirements will differ in complexity and amount. The structure completion dates have been tentatively established for one each in May and June 1963, contingent upon more definite systems support information. Final completion dates are being negotiated also to allow for systems installation and checkout operations.

The mock-up program was highlighted by the completion of mock-up 9 (transportation and handling), and evaluator 5. Other notable mock-up activity last month was the completion of the mock-up 11 structure and expedited effort to complete mock-ups 18, 2, and 11 for inspection by NASA on 15 December.

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Table 14. Apollo PMP Milestones

Command Module Structure and Subsystem Installation

Event No.	Milestone Description	Date Schedule	Date Actual
37-226-P	Complete - Manufacturing Command Module (Boilerplate 1)	1 Oct 62	
37-116-D	Complete - Airframe Command Module Crew Couch Mechanisms Design Criteria	12 Oct 62	
37-074-D	Complete - Boilerplate 14 Command Module Structure Design	26 Oct 62	
37-131-D	Complete - Airframe Command Module Definitions of Substructure & Ablative Material Attachment	26 Oct 62	
37-237-P	Complete - Assembly Command Module Structure (Boilerplate 2)	1 Nov 62	
37-016-D	Complete - Command Module Mechanisms, Basic Study	2 Nov 62	2 Nov 62
37-066-D	Complete - Boilerplate 12 Command Module Structure Drawing Release	2 Nov 62	
37-099-D	Complete Boilerplate 15 Command Module Structure Drawing Release	2 Nov 62	
37-115-D	Complete Airframe Command Module Crew Couch Mechanisms Basic Study	2 Nov 62	2 Nov 62

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Table 14. Apollo PMP Milestones

Command Module Structure and Subsystem Installation (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
37-121-D	Complete - Airframe Command Module Mechanisms Basic Study	2 Nov 62	2 Nov 62
37-072-D	Complete - Boilerplate 13 Command Module Structure Drawing Release	9 Nov 62	16 Nov 62
37-085-D	Complete - Boilerplate 23 Command Module Structure Drawing Release	9 Nov 62	
37-132-D	Complete - Airframe Command Module Definitions of Ablative Heat Shield Tile Plane Geometry (Avco)	15 Nov 62	
37-076-D	Complete - Boilerplate 14 Command Module Structure Drawing Release	19 Nov 62	
37-241-P	Complete - Assembly Command Module Structure (Boilerplate 6)	20 Nov 62	
37-255-P	Complete - Assembly Command Module Structure (Boilerplate 19)	25 Nov 62	
37-240-P	Complete - Manufacturing Command Module Boilerplate 3	1 Dec 62	

Table 14. Apollo PMP Milestones

Command Module Structure and Subsystem Installation (Cont)

Event No.	Milestone Description	Date Schedule	Date Actual
37-238-P	Complete - Manufacturing Command Module Boilerplate 2	7 Dec 62	
37-017-D	Complete - Command Module Mechanisms Design Criteria	7 Dec 62	
37-122-D	Complete - Airframe Command Module Mechanisms Design Criteria	7 Dec 62	
37-243-P	Complete - Assembly Command Module Structure Boilerplate 9	15 Dec 62	
37-117-D	Complete - Airframe Command Module Crew Couch Mechanisms	15 Dec 62	
37-139-D	Complete - Airframe 001 Command Module Structure Drawing Release	31 Dec 62	
37-140-D	Complete - Airframe 001 Command Module Heat Shield Structure Assembly and Installation Drawings	31 Dec 62	
37-147-D	Complete - Airframe 009 Command Module Structure Drawing Release	31 Dec 62	

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Table 14. Apollo PMP Milestone

Command Module Structure and Subsystem Installation (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
37-149-D	Complete - Airframe 009 Command Module Heat Shield Structure Assembly and Installation Drawings	31 Dec 62	
37-155-D	Complete - Airframe 006 Command Module Structure Drawing Release	31 Dec 62	
37-157-D	Complete - Airframe 006 Command Module Heat Shield Structure Drawing Release	31 Dec 62	
37-164-D	Complete - Airframe 004 Command Module Structure Drawing Release	31 Dec 62	
37-166-D	Complete - Airframe 004 Command Module Heat Shield Structure Assembly and Installation Drawings	31 Dec 62	
37-180-D	Complete - Airframe 005 Command Module Structure Drawing Release	31 Dec 62	
37-182-D	Complete - Airframe 005 Command Module Heat Shield Structure Assembly and Installation Drawings	31 Dec 62	
37-190-D	Complete - Airframe 010 Command Module Structure Drawing Release	31 Dec 62	

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Table 14. Apollo PMP Milestones

Command Module Structure and Subsystem Installation (Cont)

Event No.	Milestone Description	Date Schedule	Date Actual
37-192-D	Complete - Airframe 010 Command Module Heat Shield Structure Assembly and Installation Drawings	31 Dec 62	
37-199-D	Complete - Airframe 008 Command Module Structure Drawing Release	31 Dec 62	
37-201-D	Complete - Airframe 008 Command Module Heat Shield Structure Assembly and Installation Drawings	31 Dec 62	
37-208-D	Complete - Airframe 011 Command Module Structure Drawing Release	31 Dec 62	
37-210-D	Complete - Airframe 011 Command Module Heat Shield Structure Assembly and Installation Drawings	31 Dec 62	
37-217-D	Complete - Airframe 002 Command Module Structure Drawing Release	31 Dec 62	
37-219-D	Complete - Airframe 002 Command Module Heat Shield Structure Assembly and Installation Drawings	31 Dec 62	

REQUIREMENTS AND ANALYSIS

Structural Methods and Criteria

The shell displacement matrix analysis developed to make stress analyses of the aft heat shield has been programmed for the IBM 7090 digital computer. A similar analysis is being developed for conical shell structures. It will be applied to the command module forward heat shield and inner cabin. Another analysis has been developed to define stress distribution through the thickness of the ablative heat shield substrate composite. This analysis is particularly applicable in determining the influence of temperature on the composite.

Analyses are being made to define the load distribution at lift-off as influenced by the sudden release of pad restraints on the booster. An investigation of loads at the maximum dynamic pressure condition has been made, using latest wind tunnel data.

A parametric study of the docking maneuver loads also is being made. Docking concepts under investigation include free fly-around, tethered fly-around, and mechanical repositioning.

Structural design criteria for internally-attached equipment support design was revised because of impact attenuation removal during earth landing. Formal release of this criteria, including pertinent acceleration data, is being prepared.

A review of all structural design criteria contained in the Preliminary Apollo Spacecraft Requirements Specification has been made to determine how extensively the criteria will need to be revised to bring them up-to-date.

Formulation of more up-to-date impact loading criteria for the main structural members of the command module is in process.

Design criteria definition for meteoroid protection was started. The environmental model presently defined by NASA will be used, together with the present state-of-the-art for penetration mechanics.

Structural Analysis

Inner Structure Sidewall

The lower bulkhead ring has been analyzed for discontinuity stresses resulting from internal pressure. A study of the 99 percent wind condition indicates that longeron loads are equal to those used for design. The analysis of the tension ties which replace the shock struts and fittings has been completed.

Crew Couch System

The reanalysis of the Y-Y attenuator for the condition of 5 degrees rotation of the couch about the X-X axis has been completed.

Aft Heat Shield

Relocation of the umbilical plug is being considered as a result of the latest internal loads analysis of the aft heat shield for the pad abort condition. The analysis indicates a heavier structure would be necessary if the present umbilical plug location were retained.

Brazing the spherical portion of the aft heat shield in one piece instead of welding it together in four segments is another consideration under study. If feasible, this method would yield a weight saving due to elimination of the thick weld bands.

A method for attaching the non-deployable aft heat shield to the inner structure will be analyzed. This method employs a Fiberglas spacer and bolts which attach directly to the inner cabin aft bulkhead ring.

The aft heat shield will be re-investigated for areas of possible weight reduction.

A study will be made to determine the tension capabilities of tee sections bonded to honeycomb panels.

Studies for mechanical means of relieving both the elevated and cold-soak-temperature-induced loadings will continue. A design concept promising efficient solution will be proposed during the next reporting period.

Crew Compartment Heat Shield

The reaction motor support panel casting and Xc shear tie web have been analyzed. Preliminary thermal loading analysis indicates high interaction loads between the heat shield and the inner cabin structure in the area from Xc=23 to Xc-43.

Forward Heat Shield

The heat shield tie down casting has been enlarged due to the requirement for ablative material on the launch escape tower leg. The ring at Xc=81.00 has been redesigned to provide hoop continuity, which results in reduced radial reflections. The stress analysis of the command module rocket engine has been completed with the exception of the fitting that connects the support structure to the crew compartment inner structure.

All areas of the forward heat shield structure will be investigated for possible weight reduction. Face sheets and tie-down castings are the primary targets for this investigation.

Structural Dynamics

A complete analysis reveals that the command module has two stable flotation attitudes based on the present center-of-gravity location. Correlation between initial calculations and experimental results for boilerplate 25 has been obtained.

Thermodynamic Analysis

Steam Vent Line

Alternate designs of the command module steam vent are being investigated. The present concept of penetrating the heat shield with the vent line provides a direct path for the plasma sheath to enter the manned pressure vessel in the event of valve leakage.

Propellant Line Clamps

A preliminary study indicates that the maximum expected temperatures of the cotton fabric phenolic resin-laminated clamps of the command module is 225 F if the heat shield is ejected during parachute deployment and 160 F if the heat shield ejection mechanism is not used.

Temperature and Thermal Analyses

Temperature histories and thermal requirements of the aft compartment frame will be determined, and a detailed study of the temperature histories of the observation windows will be conducted.

A thermal study of the earth landing system pressure sensors will be undertaken, and thermal study of the radome will begin.

Weight Analysis

Weights

The current command module weight is 8760 pounds, taking into account incorporation of the high density ablator and deletion of the impact attenuation system struts.

Weight evaluation studies of the command module structure are being performed to determine the effect of the impact attenuation system deletion.

Center of Gravity

The revised offset center of gravity (Zc=+8.2) represents a much improved location for flight performance and stability.

DESIGN STATUS

Structural Design

Heat Shield

Aft Compartment. All removable landing impact attenuation shock strut attach fittings have been eliminated and their requirements cancelled. Dual purpose fittings are being redesigned. Facing sheet lands and densified core, which provide for attachment of these fittings, will be retained.

A total of 21 aft compartment heat shield (spacecraft) drawings have been released. The aft compartment heat shield assembly drawing is in preparation.

The aft compartment control layout for equipment will be revised to remove the shock attenuation system and to show tie rods for retaining the heat shield. The space presently occupied by the shock attenuation will be coded in such a manner that major equipment cannot be installed in that area.

The water tank support layout will be revised to reflect the new configuration when the aft compartment equipment arrangement is established.

Changes to released aft compartment heat shield facing sheet and panel assembly drawings will be prepared. Provisions for C-band antennas, electrical umbilicals, coaxial cables, hard lines, and tension ties will be added.

A feasibility study will be prepared to determine if the aft compartment heat shield can be attached to the inner structure by a series of clips located circumferentially around the aft bulkhead. These clips would be used in conjunction with the three direct command-to-service module tension ties.

Forward Compartment. The control layout defining the structural and thermal configuration in the launch escape tower leg wells area has been completed. It will undergo detailed thermal analysis.

Twenty-seven forward compartment heat shield drawings have been released. The forward compartment heat shield assembly and engine support assembly drawings are in preparation.

A static pressure sensing system layout for the parachute altitude baroswitches will be studied.

A layout will be made to show the combined tube and wire routing in the forward compartment.

A study will be made to determine the best method of eliminating the command module apex-forward stable condition during abort. Several appendages, fins, or protruberances will be considered.

Forward Bulkhead. A study of the shear tie for the forward heat shield will be prepared. The object of the study is to define a satisfactory tie without drastically affecting the longerons.

Crew Compartment. The pitch and yaw control engine support casting has been released. Design of the aft equipment shear web support structure is progressing—93 drawings have been released.

An investigation will be conducted to determine the effect of the thermal stresses induced in the heat shield structure throughout the full temperature range of -260 F to +600 F.

Roll control engine support casting layouts will be completed. A mock-up of the casting will be made to provide visual aids in simplifying the design and subsequent manufacturing operations.

Inner Structure

Aft Sidewall. The layout of the aft sidewall has been completed with the final definition of electrical, hard line, and co-axial locations, including design of the required fittings.

Forward Sidewall. The former blowout panel area is being redesigned to incorporate honeycomb construction throughout, which will result in a weight saving.

Steam Vent Line. The overboard steam vent line will be re-routed or re-sized, and some or all of the waste system penetrations will be deleted.

Tension, compression, shear, and torsion loads between the aft sidewall and forward bulkhead will be accommodated.

Crew Hatch and Center Window

The hatch locking mechanism design and the design for the crank and sequencing mechanism are 50 percent complete.

Designs for the window latching mechanism, the heat shield locking mechanism and the window drive mechanism are 25 percent complete.

System Support and Secondary Structure

A tabulation of volume and centroid locations of all equipment and structure in the aft compartment has been prepared. This layout relocates equipment near the +Zc axis.

Design layouts of the umbilical area, raceway, and electrical wiring of the aft compartment were completed.

A barrier to prevent fuel and oxidant mixing in the event of tank failure on landing was incorporated on mock-up 18.

Mechanism Design

Spacecraft Crew Couches

The requirement for obtaining 10 inches of additional couch travel in the +Z -Z direction (for suitable spacecraft center-of-gravity shift during reentry) resulted in a substantial redesign of the couch positioning mechanism and couch folding capabilities. The couches now fold to give a seat-to-back angle of 86 degrees. The foot rests have been modified to permit the 10-inch couch travel without interfering with the sextant installation.

The couch being prepared for mock-up 18 is a fully articulated metal couch that simulates the spacecraft design.

Man-to-seat loads for the crew couch are being determined for the 86 degree seat-bottom-to-seat-back angle that exists at earth impact.

A full evaluation will be made of all angular and linear adjustments on the mock-up couches. Areas of body support in the knees-up reentry and landing impact positions will be studied to determine if sufficient thigh support is obtained in these critical positions. The adequacy of adjustment control handles and knobs will be checked out.

Discone Radome Attachment

The detail drawings for the locking mechanism on the forward hatch breech lock cover are 40 percent complete.

The new loads calculated for latching the radome to the heat shield necessitate six screw-type latches located near the radome-heat shield parting lines.

New concepts for a remote-controlled radome hinge for docking will be investigated to determine if the hinge cut-out in the heat shield can be eliminated.

Space Bearings

Space bearing tests will be made on flexible cables and roller chain assemblies to determine hard vacuum effects.

Crew Hatch Mechanism

A design incorporating the quick release of the hatch with the operation of the center window cover has been prepared. Drawings were released for analysis, and target weights and criteria were established.

Efforts will be made to decrease the size, weight, and complexity of the hatch operating and sequencing mechanism in order to meet weight and thermal requirements. The most critical parts, the wobble gears and bellows seal, will be manufactured and tested.

Astro-Sextant Door Mechanism

Analytical groups were supplied design prints of the latches and hinge mechanism, and a drawings list, target weights, and list of criteria were established.

Design effort will be applied on a mechanism for transmitting torque from the motor to the door-operating linkage.

Center Window Cover Mechanism

The design mechanism for the center window will be redesigned into two sections which will mate with each other when installation is made.

Rendezvous Window Cover Mechanism

A drawings list was made and target weights were established.

Orientation Window Cover Mechanism

Two new designs are being made because of the recent changes in criteria. Target weights were established.

TEST STATUS

Boilerplates and Major Tests

Command module 1 has been subjected to an initial series of water and land impact tests with only minor damage. The module is being readied for further tests.

Command modules 3 and 19 are being modified to provide the latest spacecraft parachute attach points.

Boilerplate 14 initial basic structure is now 100 percent released for fabrication. Layouts of the forward compartment structure, crew compartment removable skin panels, and aft compartment structure drawings for boilerplate 14 (house spacecraft 1) will be prepared.

Fabrication of the basic structure for boilerplate 6 continued. All systems support structure and ballast drawings have been released.

Fabrication of the basic structure for boilerplate 9 proceeded satisfactorily and will be completed during the next report period. Ballast details and installation drawings have been released.

Fabrication of the basic structure for boilerplate 12 has begun, and the system support structure design is in preparation. All basic structure drawings have been released.

Boilerplates 13 and 15 basic structure drawings are 100 percent released. System support structure layout and design is complete and drawings are in preparation. The installation drawing for external insulation is complete.

Basic structure drawings for boilerplate 23 are being completed.

A heat transfer study of boilerplates 6 and 20 (pad abort articles) indicates that no insulation is required to hold the structure temperature below 250 F.

Crew Couch Boilerplates

Access to the lower carry-through beam was increased by a slight redesign in the lap belt support gusset.

In support of drop test 6, the Y-Y attenuation system was added to the weighted platform that simulates the boilerplate crew couches and the anthropomorphic dummy installation.

The first set of boilerplate crew couches was delivered. Some reworking is required before installation. The upholstery on the crew couch seat bottom will be changed. Two handles will be added to facilitate removal of the wooden block that simulates the survival kit and seat upholstery as a unit.

The crew couches for boilerplate 2 are approximately 65 percent complete.

Simulators

The requirement for 30 degrees rotation of the command module pitch axis was deleted.

Simulators 1 and 2 were redesignated as boilerplates 26 and 27.

Drawing releases for these articles are 70 percent complete.

Apollo Test Requirements (ATR) Program

All forward compartment heat shield spacecraft drawings in support of the manufacturing schedule for the ATR program have been released.

The aft bulkhead assembly and details for ATR 301-3 were revised to agree with the new distributed load system.

All structural and mechanical device test requirements related to shock attenuation system were revised to conform to the current design approach to earth impact problems.

Major structural component test requirements (ATR 209, 210, and 211) have been released for laboratory action.

Ground Tests

Aft Heat Shield

The spacecraft aft heat shield release mechanism design is complete. This design philosophy is based on non-removal of all impact attenuation provisions in the command module. The drawings will help provide adequate provisions for impact attenuation installation in the spacecraft should that system be restored.

The aft heat shield release mechanism component tests (ATR 109-1) were successful. Test verification of design assures heat shield release performance of boilerplates 3 and 19 for the repetitive parachute drop program.

Interim Drop Tests

The interim boilerplate drop test program (ATR 201-A) continued with drop test 5 (the first land drop) and drop test 6 (check-out of instrumentation for the first moving crane land drop). These tests were successful.

Two associated tests to ATR 201-A were performed. Three dry runs were conducted to investigate effects of horizontal velocity on stability of the boilerplate. The boilerplate was suspended from a moving crane traveling at forward speeds up to 17.6 feet per second.

A coefficient of friction test of the heat shield (with command module weight) using surfaces of asphalt and Downey silt loam was made.

Preliminary evaluation of the load levels from the first land drop of boilerplate 1 indicates substantiation of analytical predictions.

Structural Panels

Acoustic and vibration tests of ablative coated heat shield panels have been initiated to obtain data on the response characteristics, transmissibility, and damping.

Crew Couch Shock Struts

The crew couch shock struts will be redesigned for correlation with an analytical program aimed at defining all the landing conditions under consideration. The redesign will use crushable honeycomb for primary attenuation and a friction of frangible device for reverse attenuation. The total system incorporates a mechanical lockout device for reentry loads. In addition, redesign will incorporate results from the component testing of the struts.

Materials

Sandwich Structures

A test program to develop new and improved analytical methods of stress analysis on sandwich structure is being instituted.

Fasteners

A complete test program for all types of fasteners and spacer inserts is under way. Three programs are partially completed.

A program to develop a metallic coating for high-strength fasteners has been initiated .

Adhesives

All adhesives used for bonding aluminum honeycomb structure are being reevaluated because of recent test panel failures.

A new specification for bonding is being prepared using HT424 instead of FM-1000, which is adversely affected by moisture.

Vapor Study

A preliminary study was made to show the effects of nitrogen tetroxide vapor and Aerozine on nylon. The nitrogen tetroxide vapor showed severe deleterious effects.

Welding

Fusion weld tests on the 2014-T6 flash-welded inner rings have been completed. The fushion weld was sufficiently strong. Further metallurgical investigation is in progress.

Brazing

A Rene 41 braze honeycomb sandwich panel produced by the Nortobraze process is undergoing mechanical property tests.

[redacted]

An investigation is under way to determine if the brazing cycle for PH15-7Mo can be altered to lower the present ductile-brittle transition temperature (approximately -100 F) of the sandwich structure.

Forgings

Welding tests of eight rolled-forged 2014-T6 rings are being performed. Metallographic examination of the rings demonstrated good grain size.

Window Coatings

A plan-of-action for the investigation of coatings for the command module window was issued. The coatings will reduce ultraviolet transmission and glare.

Seals

Two prototype window seals have been injection-molded with RTV-560. No difficulties were encountered with air entrapments, curing, or injection techniques. RTV-560 is being tested for mechanical properties at cryogenic temperatures.

Parker Gask-O Seals were selected as the primary candidate for sealing the electric plugs in the command module wall. They will be tested environmentally.

Elastomers

Sixteen elastomers have been evaluated at room temperature in ultra-high vacuum (10^{-9} Torr). Investigations are being started to determine weight losses in ultra-high vacuum at elevated temperatures.

Panels

Phase I (a feasibility study) of the program to evaluate L-605 alloy honeycomb panels was completed. The study included selection of a suitable etchant composition and determination of the control range necessary for the chem-milling.

Further testing of L-605 honeycomb panels was cancelled.

The Rene 41 honeycomb panels test program was revised.

Evaluation of formed and unformed PH15-7Mo Stressskin panels was completed. Results indicate control problems in the fabrication process.

Space Radiation Simulation

The over-all history and general plan-of-action for exposure of Apollo materials to simulated electron-proton space radiation has been completed.

Test Program

A test program for subjecting a hemispherical nickel monocoque dome and a hemispherical sandwich dome to non-uniform internal pressure and thermal gradients has been written.

SERVICE PROPULSION SUBSYSTEM

REQUIREMENTS AND ANALYSIS

Milestones completed during November and those scheduled for December are shown in Table 15.

Procurement

The Apollo spacecraft service module propulsion system rocket engine specification has been released to the subcontractor.

Invitations to bid on the helium solenoid shutoff valve and check valves have been sent to potential suppliers.

Quotations for the helium system regulator have been received.

Propellant Utilization

Automatic propellant utilization requirements have been deleted from the work statement. This contract change has been implemented by revising the initial specification for the automatic propellant utilization and quantity gaging system. The revision specifies the requirements for a gaging system and an associated crew-operated flow control valve.

The length of the fuel line from the tank to the service propulsion engine is being reduced to decrease weight and improve operation.

The temperature of the helium entering the propellant can be increased by incorporating helium/propellant exchangers in the propellant feed lines.

An analysis of series versus parallel propellant feed-out from the storage tanks is continuing.

The total system weight is comparatively insensitive to helium storage pressure in the range of 2500 to 5000 psia.

During the next report period, the procurement specification for the propellant quantity gaging system and the associated crew-operated flow-control valve will be released.

Table 15. Apollo PMP Milestones
Service Propulsion Subsystem

Event No.		Date	
	Milestone Description	Schedule	Actual
38-049-D	Complete - Firm Basic Configuration Propellant Feed System	1 Nov 62	1 Nov 62
38-050-D	Start - Propellant Feed Studies	1 Nov 62	1 Nov 62
38-023-D	Complete - Spacecraft Interface Establishment	15 Nov 62	15 Nov 62
38-025-D	Complete - 100 Percent Design Release Test Fixture Preflight Rating Test	15 Nov 62	21 Nov 62
38-035-D	Start - Gimbal Actuators Structural Integrity Verification	1 Dec 62	
38-041-D	Complete - Material and Processes Specifications	15 Dec 62	
38-008-D	Complete - Subscale Chamber Demonstration - AECD	15 Dec 62	
38-012-T	Complete - Testing Alternate Chamber Materials	15 Dec 62	

Gimbal Actuator

S&ID has decided to sum the gimbal actuator feedback loop in an amplifier employing 400 cycles a-c power and supplying d-c control current to the actuator clutches. A malfunction in the gimbaled engine loop will be sensed and a switching circuit will change from the operating channel to the standby channel.

Copies of the subcontractor procurement specification for the gimbal actuator system have been submitted to NASA. A summary report of S&ID effort in the selection of an electro-mechanical system and an associated failure mode analysis were also submitted.

The gimbal actuator specification is 85 percent complete.

Thermal Effects

The radiant heating of the service module aft bulkhead by the radiation-cooled nozzle extension of the service propulsion engine is being analyzed.

SUBCONTRACTOR ACTIVITIES - AEROJET GENERAL CORPORATION

Mock-ups

A hard mock-up was delivered and inspected during November. It may prove desirable to change the location of some of the propellant lines and valves as a result of the analysis performed on the mock-up.

One major change to the service propulsion engine is under study as the result of S&ID hard mock-up review. This change involves the repositioning and repackaging of the propellant control valves.

The mock-up design review also generated minor changes which were resolved by S&ID and the subcontractor.

Test Fixtures

Detail designs of test fixtures 1 through 3 for service propulsion system development and qualification testing are complete. Forty percent of off-the-shelf components for these fixtures have been received and are being tested for acceptance.

Test firing of subscale engine hardware started at Tullahoma during November. Preliminary data from these tests indicate that it may be desirable to change the nozzle material from titanium to columbium.

Propellant Utilization

Design layouts to incorporate a helium heat exchanger in both the fuel and the oxidizer lines are in progress.

During the next report period, heat exchangers mounted in the propellant distribution lines will be compared with the direct-contact bubbler-type heat exchanger.

Gimbal Actuator

The travel requirement was reduced from ±10 degrees, plus 1 degree snubbing, to ±8 degrees 30 minutes, plus 1 degree snubbing.

Analysis

The service propulsion engine test plan, including development and qualification, will be reviewed during the next report period. The service propulsion engine model specification will also be reviewed.

An analysis of the requirement for a close-out shield between the service propulsion engine and the module at the aft end of the engine compartment will continue.

RELIABILITY

The reliability allocation of the service propulsion engine has been revised from 0.999910 to 0.999900, to account for the propellant lines and drain lines recently incorporated into the engine. This reliability allocation is based on a failure rate of four failures per million missions for each propellant line and two failures per million missions for the six drain lines. A high apportionment is required for these lines because of the critical nature of a single failure.

The reliability analysis has been extended to project engine reliability over a period that covers 336 hours elapsed mission time, including a total engine firing time of 750 seconds.

Major engine-component reliability allocations will be reviewed.

TEST STATUS

Ground Tests

Injector

Significant progress has been made in the service propulsion engine injector development program.

Stable combustion has been attained with a long impingement triplet injector. This concept was incorporated in the first Apollo prototype aluminum injector after it had been tested in a stainless steel unit. The injector was retired after a total of 52 seconds of accumulated operation. Performance based on this limited testing appears to approach Apollo requirements.

A baffled revision of this injector has also been fired. This unit successfully demonstrated recovery to stable operation after it had been subjected to an 80-grain powder charge pulse while being fired in a stability evaluation chamber.

Ablative Chamber

Three firings were made on a full-scale ablative chamber for a total duration of 165 seconds. This time period was in addition to the 125 seconds firing previously accomplished.

Due to combustion instability, the chamber separated at the interface between the ablative material and the injector-end flange. The instability was revealed by post-run inspection of oscillographic data.

Simulated Altitude Tests

The first firing of the sub-scale simulated altitude program was conducted at the Arnold Engineering Development Center (AEDC). An ablative chamber with an uncooled titanium nozzle extension was fired for 750 seconds. The chamber-to-nozzle extension interface on this chamber was located at the 6:1 expansion-ratio plane. The nozzle extension employed a 60:1 expansion ratio with a 15-degree included half angle.

Overheating occured in the nozzle extension, measured temperature near the attached flange reached more than 2100 F, and localized burn-through resulted during the last three mission firings.

The subscale test program at AEDC will be completed, and test-data evaluation will be initiated during the next report period.

Materials

Butyl rubber and modified Teflon are being evaluated as "O" ring seal materials for use with nitrogen tetroxide under varying conditions of temperature and pressure exposure time. Preliminary tests indicate that the Teflon "O" ring is superior to the Butyl rubber.

REPORT ON DELETION OF AUTOMATIC PROPELLANT UTILIZATION

The automatic propellant utilization system was deleted per NASA direction. A technical study was made to determine the effect of the change and to perform a comparison of a propellant utilization system having no flow control provisions with a system using a manually-operated flow control device. Comparison factors were spacecraft earth-escape weight, reliability, operational considerations, and cost. Results of the study indicated that complete deletion of the propellant utilization system would result in severe burn-out weight penalties, reduce the probability of crew survival and mission success, and require more complex system checkout equipment and prelaunch operations than for either the fully automatic or manually controlled propellant utilization systems. Significant points in the impact statement were that the automatic propellant utilization system would be replaced with a system using manual flow control and providing a propellant indicating system with crew display of quantity remaining and mixture ratio.

The change will result in a slip in contract award of approximately 10 weeks for the propellant utilization system. This slip will be due to revision and reissue of the procurement specification for the subject system and the evaluation of new proposals.

SERVICE MODULE STRUCTURE AND SUBSYSTEM INSTALLATION

Milestones completed during November and those scheduled for December are shown in Table 16.

FABRICATION

The service module for mock-up 9 was completed, and expedited effort continued on the installation of systems in mock-ups 18 and 11. Progress was made on the major subassemblies of the boilerplate 9 service module.

Accomplishments scheduled for the next report period include completion of installations on mock-ups 18 and 11 and delivery of mock-up 7A to Engineering. Work is being completed on service module 7 for boilerplate 9.

REQUIREMENTS AND ANALYSIS

Internal Loads

New loads are being generated using an unsymmetrical geometry program. This program will be concurrent with the existing symmetrical geometry program, which has had a successful run.

A separate program was written to calculate the pad loads at the command module/service module interface. The outer shell is being considered as a continuously-stressed shell taking body and pressure loads.

Aerodynamics

A study was made of the service module and adapter internal pressures during boost. Each was considered as a separate chamber with no flow exchange between them. The vents were located in close proximity forward and aft of the service module aft bulkhead-adapter junction, and external shields were added to negate angle-of-attack effects. The peak ΔP occurs approximately 70 seconds after lift-off.

[redacted]

Table 16. Apollo PMP Milestones

Service Module Structure and Subsystem Installation

Event No.	Milestone Description	Date	
		Schedule	Actual
39-021-D	Complete - Service Module Boilerplate 14 Structure Drawing Release	16 Nov 62	
39-010-D	Complete - Service Module Boilerplate 9 Assembly and Installation Drawings Release Separation System	30 Nov 62	
39-018-D	Complete - Service Module Boilerplate 13 Assembly and Installation Drawing Release Separation System	30 Nov 62	
39-034-D	Complete - Service Module Boilerplate 15 Assembly and Installation Drawing Release Separation System	30 Nov 62	
39-038-D	Complete - Service Module Boilerplate 16 Assembly and Installation Drawing Release Separation System	30 Nov 62	
39-042-D	Complete - Service Module Boilerplate 18 Assembly and Installation Drawing Release Separation System	30 Nov 62	
39-084-D	Complete - Assembly Service Module Structure Boilerplate 9	17 Dec 62	
39-014-D	Complete - Service Module Boilerplate 12 Assembly and Installation Drawing Release Separation System	31 Dec 62	
39-026-D	Complete - Service Module Boilerplate 23 Assembly and Installation Drawing Release Separation System	31 Dec 62	
39-030-D	Complete - Service Module Boilerplate 22 Assembly and Installation Drawing Release Separation System	31 Dec 62	

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Atmospheric Heat Transfer

The maximum temperature of the service module honeycomb shell structure during boost will be 390 F at the outer face sheet. The maximum ΔT across the panel is 75 F, based on one inch thick honeycomb panels with 0.015 face sheets.

Thermodynamics

A computer study is under way to predict reaction control system (RCS) plume characteristics which supply impingement data. Plans are being formulated to conduct analysis tests to determine outer shell and internal insulation requirements for the full mission. Outer shell thermal studies will continue on establishing plots of permissible time-temperature versus RCS hot gas impingement.

An analysis based on view angle is underway to establish the effect of the service propulsion system (SPS) engines' heating rate on the aft bulkhead.

Analysis

The stress analysis of the revised shell panel test part was completed.

The stress analysis of the following boilerplates was completed:

(1) 12, 22, and 23—Little Joe II

(2) 9, 13, 15, 16, and 18—C-1

The service-module-to-adapter interface connection was resized to reflect the new configuration.

A diffusion analysis will be made to determine how the SPS tank loads are reacted by the radial beams.

The forward bulkhead IBM program was completed; the detail stress check is approximately 30 percent complete.

The aft bulkhead preliminary analysis was completed; detail analysis is approximately 30 percent completed. Portions of the bulkhead are designed by dynamic vibration loads. A dynamic study of the fuel cell mounts is underway.

A stress analysis was made of three different main propellant tank doors: conical, flat plate, and dome.

Weights

A weight trade-off study was made to show the difference between 99 percent and 95 percent winds at lift-off. The increased weight would be very small.

The current service module burn-out weight of 10,765 pounds is slightly less than that previously reported. This is due to the deletion of the five-pound thrust reaction control engines.

DESIGN STATUS

Radial beams 3 and 6 were completed.

The shell test panel, Apollo Test Requirement, was revised to meet the new continuously-stressed shell requirement.

The aft bulkhead test panel was revised to the continuously-stressed shell load transfer from service module to adapter. All drawings of the test bulkhead and simulated adjacent structure were released.

The radial beam test will use production radial beam 6. The original test beam had a concentrated load transfer to the adapter and was based on the shorter service module.

Radial beams 2 and 5 were changed to numerical-control-machined beams because no weight saving was obtained using honeycomb panels. All beams are now machined from 7075 T6 aluminum plate.

The service module/command module compression shear plug proposed by Avco necessitates minor redesign of the upper truss of radial beams.

A design study of the mounting provisions for the propellant fill engine valves check-out and drain connectors was completed.

The design layout of the main propellant vent system mounting provisions was completed.

TEST STATUS

Boilerplates and Major Tests

All boilerplate structural drawings were released. Drawings of the insert for orbital test articles and the ten-inch extension for the abort test articles were also released.

All drawings on the separation system for boilerplate 6 are released.

The layout and detail drawings were completed for the release system for boilerplates 9, 12, 13, 15, 16, 18, 22, and 23.

Boilerplate 14 (initial basic structure) is 100 percent released for fabrication.

Ground Tests

All test requirements for service module laboratory tests were reevaluated and revised to the latest design configuration.

Test fixtures are being revised to accept the redesigned test parts of the service module cover door, aft bulkhead, and radial beam.

Simulated service-to-command module umbilicals were tested, using shaped charges of 50 and 100 grains per foot surrounding the bundle.

Material

The general specification for the Apollo command and service module pressure vessels was completed and issued.

A study was initiated to determine the applicability of ultrasonic and radiographic inspection to pressure vessels.

A test program was initiated to determine the cryogenic mechanical properties of extra-low interstitial Ti-5Al-2.5Sn and Ti-6Al-4V hand forgings. Both the parent metal and weld properties will be determined. A material specification for ELI Ti-5Al-2.5Sn was released.

A study is under way to determine the feasibility of shear-spinning cylindrical portions of the main propellant tanks out of Ti-6Al-4V.

Inconel 718 is being evaluated to determine whether or not it can be used in lieu of Inconel "X" at a higher strength-to-weight ratio in oxygen pressure vessels.

A test program was initiated to evaluate the applicability of electron-beam welding and gas pressure bonding to the production-design coldplates.

A compatibility of oxygen-free, high-conductivity copper in pressurized hydrogen and oxygen was completed. Because the study shows no deleterious effects, this material will be recommended for bushings in the propellant system.

The study of 6061 aluminum tubing compatibility in the environmental control system (ECS) unit with circulating fluids (urine, Wescodyne, KOH, and Freon 114) was concluded. Appreciable corrosion of the 6061 tubing due to contact with these fluids is not anticipated, with the exception of KOH, which may cause pitting of the 6061 material. Chemical inhibitors for the water-glycol systems are now under study.

An evaluation of commercial gold-base brazing alloy joints in pressure systems and propellant systems was conducted. Flow tests on simulated production joints revealed that one of these gold base alloys, Nicoro 80, gave superior performance. Compatibility tests in nitrogen tetroxide and unsymmetrical dimethylhydrazine/Aerozine 50 indicated zero weight loss in joints brazed with Nicoro 80.

Compatibility tests between monomethyl hydrazine and elastomers were started. Of the seven elastomeric materials evaluated, five showed less than eleven percent volume increase.

A rotary feed-through apparatus for evaluating high-vacuum friction and wear phenomena was designed and fabricated.

SUBCONTRACTOR ACTIVITIES

Requests for bids on the SPS tanks were distributed. Approximately 14 suppliers are expected to submit bids.

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ELECTRICAL POWER SUBSYSTEM

REQUIREMENTS AND ANALYSIS

The milestones completed in November and these planned for December are depicted in Table 17.

Pyrotechnics

Procurement specifications were prepared for the exploding bridge-wire (EBW) firing unit, EBW initiator, and hot wire initiator. The ground rules were established with GSE on the ground-checkout concept of respective systems.

Checkout procedures for both the hot wire and EBW system will be developed for boilerplate 6.

Studies were initiated to investigate the pyrotechnic requirements for the separation of the service module, adapter and booster, and the "break-up" of the adapter.

An investigation was initiated to determine the impact of inclusion of the explosive bolts as a back-up to the mechanism in the command/service module separation system and the explosive nuts as a back-up to the mechanism in the tower/command module separation system.

Sequencer

Functional requirements for the launch escape sequence and all boilerplate vehicle sequences were established, and all time delays determined. The signal level was established for the initiation of abort for the max Q abort test. Functional diagrams were prepared for boilerplates 6, 12, and 13.

An investigation was initiated to determine design requirements to implement the inclusion of explosive bolts and nuts as back-ups to the separation mechanisms.

Electrical Distribution Systems

Procurement specifications for various components of the distribution system were prepared. Revisions to the static inverter, battery charger, and battery procurement specifications also were prepared.

[redacted]

Table 17. Apollo PMP Milestones

Electrical Power Subsystem

Event No.	Milestone Description	Date	
		Schedule	Actual
40-014-D	Complete - Airframes 2, 9, 10 and 11 Sequencing System Requirements Definition	1 Nov 62	
40-029-D	Complete - Boilerplate 22 Circuit Design Sequencing System Approved by NASA	1 Nov 62	
40-057-D	Complete - Reliability Survey of Boilerplates 13, 15, 16, and 18 Sequencing System Components	1 Nov 62	7 Oct 62
40-058-D	Complete - Product Design Release Boilerplates 13, 15, 16 and 18 Sequencing System	1 Nov 62	
40-067-D	Complete - Battery Charger Subcontract Award	1 Nov 62	
40-154-D	Complete - Release Hot Wire Initiator Final Specification	1 Nov 62	
40-235-D	Complete - Fuel Cell Radiator Preliminary Design	1 Nov 62	16 Nov 62
40-142-D	Complete - Release Explosive Bridge Wire Initiator Final Specification	9 Nov 62	
40-202-D	Complete - Release Explosive Bridge Wire Firing Unit Preliminary Specification	15 Nov 62	
40-059-D	Complete - Boilerplates 13, 15, 16, and 18 Sequencing System Design Approval by Range Safety Officer	20 Nov 62	

Table 17. Apollo PMP Milestones

Electrical Power Subsystem (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
40-006-D	Complete - Product Design Release Boilerplate 6 Sequencing System	24 Nov 62	
40-004-D	Complete - Boilerplate 6 Sequencing System Breadboard Evaluation Tests	24 Nov 62	15 Oct 62
40-005-D	Complete - Reliability Survey of Boilerplate 6 Sequencing System Components	24 Nov 62	15 Oct 62
40-007-D	Complete - Boilerplate 6 Sequencing System Design Approval by Range Safety Officer	1 Dec 62	
40-015-D	Complete - Airframe 2, 9, 10, and 11 Circuit Design Sequencing System	1 Dec 62	
40-043-D	Complete - Boilerplate 12 and Boilerplate 23 Sequencing System Breadboard Evaluation Tests	1 Dec 62	
40-068-D	Complete - Battery Charger Preliminary Design Report Approved by NAA	1 Dec 62	
40-236-D	Complete - Fuel Cell Radiator Design Approval by NASA	1 Dec 62	
40-008-D	Complete - Boilerplate 6 Sequencing System Qualification Test Plan	15 Dec 62	

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Table 17. Apollo PMP Milestones

Electrical Power Subsystem (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
40-016-D	Complete - Airframe 2, 9, 10, and 11 Circuit Design Sequencing System Approved by NASA	15 Dec 62	
40-030-D	Complete - Boilerplate 22 Sequencing System Breadboard Evaluation Tests	15 Dec 62	
40-143-D	Complete - Explosive Bridge Wire Initiator Subcontract Award	15 Dec 62	
40-220-D	Complete - Release Fuel Cell Component Drawings	15 Dec 62	
40-177-D	Complete - Umbilical Service Module to Command Module Reliability Test Report Approval	15 Dec 62	
40-061-D	Complete - Manufacture of Boilerplate 13, 15, 16 and 18 Sequencing System Prototypes for Testing	15 Dec 62	

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A study was initiated to determine the feasibility of powering the pyrotechnic system from two independent sources.

A study of various methods of supplying power to the lighting system was completed. 28 volt d-c, 6 volt d-c, and 6 volt a-c lamps and dimming methods were considered. The results of the study indicate a weight saving can be achieved by using dimmable 28 volt d-c lamps.

A study was initiated to investigate various bus structures required to supply the service module propulsion system gimbal motor power.

Interior Lighting

Two types of incandescent lamps, a 28 volt lamp and a 6 volt lamp, are considered suitable for floodlighting. A trade-off study was initiated to determine the weight and reliability of each system.

Umbilicals

An analysis of the method for obtaining command-to-service module electrical separation is nearly complete.

The practicability of using through-the-hatch wiring for ground control and checkout provisions to minimize the requirement for a command module to GSE umbilical will be investigated.

Fuel Cell Systems

The fuel cell power plant procurement specification was revised and has been reissued.

A procurement specification for the fuel cell radiator was prepared and is being revised into a work statement for the fabrication of a radiator panel.

A study of the feasibility of using the General Electric Gemini fuel cell for the Apollo spacecraft was completed; the results were presented to NASA for evaluation.

A study was completed on the water production and reactant consumption rates based on electrical power requirements for the Apollo spacecraft mission.

The instrumentation requirements and test points for the fuel cell system were established. Signal conditioning requirements and environmental criteria were also established. Evaluation of reactant flow measuring instruments revealed that the heated capillary type of sensing device is a feasible approach.

Thermal analysis of a radiator design based on area sharing demonstrated this approach is feasible. It also demonstrated the need to control the radiator area to meet requirements of a lunar orbit mission. An investigation of materials and fabrication techniques for the radiator panels was conducted.

SUBCONTRACTOR ACTIVITIES

Electrical Components

Discussions were held with Westinghouse, Eagle-Picher, and International Telephone and Telegraph concerning contract negotiations, specification revisions, and details of the electrical development programs.

Fuel Cells (Pratt & Whitney)

Development work on the fuel cell program is proceeding according to schedule, and most of the critical objectives are being accomplished.

DESIGN STATUS

Pyrotechnics

Tower installation design of the EBW firing unit was established. A preliminary wiring schematic was developed for the pyrotechnic circuits, including placement of firing relays for the hot wire initiators.

Sequencer

Drawings of the sequencer for boilerplate 6 have been released.

Electrical Distribution System

A study was initiated of the distribution system to reduce the number of components, such as circuit breakers, to accomplish a weight savings.

Results of a bus feeder system performance study will be used in the development of the feeder design to accommodate better fuel cell performance.

Sensing devices will be incorporated to produce a signal under short-circuit conditions. The signal will operate a contactor, thus deleting the requirement for output circuit breakers.

Electrical Design Systems

The electrical systems design for boilerplate 6 has been released.

Procurement specification engineering requirements for the command-to-service module umbilical disconnect, aft bulkhead feedthrough, and general purpose wire were released.

A study was made to determine optimum locations for minimizing weight and installation problems of the wiring runs between major electrical power components. As a result, efforts are directed toward locating battery circuit breakers within the battery envelope. Similarly, the inverter input and output switches will be located in the lower equipment bay as close to the inverters as possible.

Fuel Cell Systems

Layouts of a 45 square-foot radiator, using area-sharing principles, and a radiator area control are being prepared. The radiator design will be revised when new thermal data are available.

The support structure design for mounting the fuel cell powerplant in the service module has been completed and drawings have been released.

RELIABILITY STATUS

Pyrotechnics

Reliability studies were undertaken to develop qualification test plans and lot acceptance test plans for the EBW initiators and the hot wire initiator. The qualification test plans are designed to demonstrate 0.99 reliability with a confidence level of 80 percent.

Sequencer

A study to determine qualification test requirements for the sequencer to yield a high reliability with a minimum number of tests was begun.

Electrical Distribution Systems

A failure mode analysis was completed for the inverter, fuel cells, and over-all electrical distribution system.

Investigation of battery design has been completed. Development test procedures for batteries are under development and will be issued during the next report period.

Reliability analysis of the distribution system will include variations in design.

Circuit breaker tests will be performed to determine their characteristic curves in a vacuum environment. A study will be made of the operating characteristics of electrical wire in a vacuum so that circuit breaker and wire characteristics may be matched either in a vacuum environment or at sensible pressure environments.

Fuel Cell Systems

Failure reports were prepared which tabulate all results from the development test to the failure program by component and failure types.

A failure summary was prepared from all single cell data. The procurement specification was rewritten, integrating qualification reliability tests as qualification tests only.

TEST STATUS

Pyrotechnics

Twenty-five EBW initiators were tested for lot acceptance. One unit misfired, but the lot was accepted with one failure in order to avoid a schedule slip of the launch escape, pitch control, and tower jettison motor development programs. A preliminary investigation indicates the misfire was a result of the cleaning process of a repaired "leaker." The cleaning process will be changed and all leakers will be rejected for lot number 2. Lot acceptance testing of lot number 2 of the EBW initiator will be performed at the supplier's facility.

Sequencer

Full-scale breadboard (including redundancy) fabrication was initiated for boilerplates 6 and 13. The breadboards will use parts identical to those used in the flight item.

Electrical Design Systems

Vibration tests indicate that the 28 volt lamp will require vibration isolation, whereas the 6 volt lamp may not.

Fuel Cell Systems

Tests were conducted on a 70 percent aqueous glycol solution to determine the volume-versus-temperature-change and phase-change characteristics. Results showed that the solution did not freeze at a temperature of -140 F and that the volume decreased with temperature decrease to the limit of -140 F.

Tests of a 62 percent aqueous glycol solution will be conducted to determine volume-change versus temperature-change and phase-change characteristics.

Tests are being conducted on single fuel cells to establish performance, endurance, fabrication, and assembly technique evaluation as well as temperature and pressure corrections of performance. Tests are being conducted also on seals, materials, and components of the fuel cell power plant. Endurance tests are being conducted on six-cell stacks. Vibration tests were conducted on the shock mounts, controls, and single fuel cells to determine the natural frequencies.

The power plant endurance test and 31-cell stack tests will be conducted. Testing of components, materials and seals, single cells, and 6-cell stacks will be continued. Layout and detail design drawings will be completed for the PC3A-2 power plant.

A qualification test program will be established for the fuel cell power plant, and the procurement specification will be revised accordingly.

REACTION CONTROL SUBSYSTEM

Milestones completed during November and those scheduled for December are shown in Table 19.

REQUIREMENTS AND ANALYSIS

Command Module

An analysis of a new configuration for the propellant feed subsystem of the command module reaction control system (RCS) indicates that the relocation of the propellant tanks will necessitate only slight modification of propellant line sizes. An investigation has been started to determine the effects of g loading on the operation of this subsystem during reentry. The normal reentry loading is expected to be as great as 10 g's. This loading will have a substantial effect on the flow rate to the roll and yaw engines because a decrease in propellant flow rates will result in a decrease in thrust level.

A parametric analysis of the command module RCS propulsion system, using the weight of the present design (which has a 150-psia chamber pressure and a nozzle expansion ratio of 40:1) as a base, shows that weight savings can be achieved by reducing the nozzle expansion ratio. Results of the analysis are summarized in Table 18.

Table 18. Parametric Analysis of Command Module RCS Propulsion System

Nozzle Expansion Ratio	Chamber Pressure (psia)	Weight Saving (pounds)
22:1	150	17
25:1	250	31
10:1	150	36
10:1	250	41

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Table 19. Apollo PMP Milestones

Reaction Control Subsystem

Event No.	Milestone Description	Date	
		Schedule	Actual
41-048-D	Start - Engine Thrust Chamber Tests (Command Module)	1 Nov 62	
41-035-D	Start - Prototype Engine Development Tests (Service Module)	12 Nov 62	
41-001-D	Complete - Release of Reaction Control System Equipment Procurement Specifications (Command Module)	15 Nov 62	
41-002-D	Complete - Release of Reaction Control System Equipment Procurement Specifications (Service Module)	15 Nov 62	
41-045-D	Complete - Place IDWA for Reaction Control System Engine - Command Module - Rocketdyne	8 Dec 62	

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Additional advantages of reduced nozzle expansion ratios include easier installation and reduced space envelopes.

The IBM program for computing plume properties by the characteristics method will be changed to incorporate a variable specific heat and variable input. The analysis to determine the effect of exhaust plume on microwave transmission will be continued.

A computer program applicable to both the service propulsion system and command module RCS engines will be formulated.

Service Module

An analysis has been completed to determine the terminal velocity of helium bubbles in the propellant tanks as affected by accelerations induced by the 100-pound thrust RCS engines.

Bubble rise time tended to converge for all bubble sizes at high induced accelerations. Bubble rise time for bubbles of various sizes tended to diverge at low induced accelerations.

When 25-pound engines were compared with 100-pound engines, no significant differences were noted in the delivered specific impulse, engine-wall temperatures, or insulation weight required to protect the service module skin from engine plumes.

A literature search and analysis to assess the safety aspects of RCS engines show that a thrust chamber rupture of the engines could be caused by overheating the chamber wall or by meteoroid impingement. Also, propellant explosions could result from an injection valve failure or overheating of the propellant lines near the engine. Further analysis and testing are necessary in order to predict explosion forces, damage, and probability of damage.

An analysis of the thermodynamic properties of the combustion gases at the exit plane of the service module RCS engines shows:

temperature = 1318 R;

velocity = 9444 feet per second;

density = 2.15×10^{-4} pounds per cubic feet.

A revised plume profile has been completed. The plume calculation included actual nozzle exit conditions and a corrected method of calculating characteristics of plume profile. This plume has been checked for mass continuity and side forces on a flat plate.

A study has been initiated to determine the radio frequency attenuation through the RCS engine plume for various service module antenna orientations. Preliminary analysis indicates that an ion density of approximately

6×10^{-10} electrons per cubic centimeter is possible at the nozzle exit plane. Collision frequencies are being calculated to determine the attenuation.

A computer program for predicting plume characteristics has been completed. Three basic assumptions made were:

1. Exhaust flow at the nozzle lip will expand, according to the Prandtl-Meyer theory.
2. Flow at the nozzle centerline will not deviate from the centerline during expansion.
3. Streamlines are hyperbolic in form. The method applies only to exhaust flow in a vacuum environment. Program options to account for the perturbations of plume profile caused by the variable ratio of specific heats, nozzle exit, Mach number, and temperature profiles are being considered.

Spacecraft

Analysis shows that the maximum allowable leakage rates of the command module and service module RCS engine injector valves are no leakage prior to launch and 0.35 cubic centimeters per hour per valve after launch. This is considered acceptable with respect to fire or explosion hazards.

SUBCONTRACTOR ACTIVITIES—ROCKETDYNE

Design of the reaction control engine for the Apollo command module has been completed at Rocketdyne. Development and production stages have been started with the initial deliveries of preprototype (nonfireable) engines scheduled for December 1962. Placement of orders for long lead time hardware items and test equipment is continuing at an accelerating pace to prevent production schedule delay.

DESIGN STATUS

Command Module

A formal cost proposal for the command module RCS engine was received from Rocketdyne. The proposal is being reviewed in preparation for negotiations with Rocketdyne.

Further optimization of the vehicle center of gravity resulted in the relocation of the propellant tankage to the extreme plus side of the aft compartment. This change necessitated revision of the equipment panel arrangement and locations, and most of the propellant plumbing had to be rerouted.

Elimination of the impact attenuation system increased g loading on the propellant system. This will be reflected in small weight penalties.

Study effort on relocating the RCS engines about the stability axes has been discontinued. Extension modification of the command module would be necessary and the propellant saving indicated is less than expected.

Service Module

A nondeployable configuration has been selected for the service module RCS. The engines will be canted and essentially surface-mounted.

The propellant tanks, pressurization system, and distribution system will be mounted inside the service module adjacent to the main propellant tanks. All modules will be interchangeable and are located 7-1/4 degrees off the principal axes. The engine cluster will be located consistent with RCS module design to minimize engine plume heating on the service module skin and radiators.

During the next period, the service module RCS propellant volumes will be finalized, and the optimum RCS module size will be established. The engine location will be determined, and the module design detailed.

The command module RCS pressure regulator, check valve, and pressure relief valve procurement specification will be released.

Breadboard Tests

The design of the breadboard test stand for the service module RCS package has been released for fabrication. The design of the command module RCS and service module RCS component installation is being changed to reflect the latest installation concepts.

A specification control drawing defining the nonfireable engine configuration was completed and forwarded to Rocketdyne. Initial delivery of six engines for use in phase I of the breadboard tests is scheduled for 1 December 1962.

Specifications

The command module RCS pressure regulator, check valve, and pressure relief valve procurement specifications are being reviewed. The service module RCS gaging system specification is 85-percent complete.

SUBCONTRACTOR ACTIVITIES—MARQUARDT CORPORATION (SERVICE MODULE)

The experimental testing phase of the development program for service module reaction control engines was completed during the report period as scheduled. Work is proceeding on the revised procurement specification and delivery schedule in accordance with the cost reductions negotiated during October.

The Marquardt Corporation has been authorized to develop a solenoid propellant valve which will be operated by one coil in the automatic mode. An additional coil will be provided for the emergency mode of operation. The purpose is to provide data on the feasibility of obtaining desired engine minimum impulse performance with this valve configuration.

RELIABILITY STATUS

Command Module

Design review of the command module RCS engine solenoid valves and thrust chamber assembly revealed several potential problem areas. Solutions to the problems were either proposed or scheduled for additional study.

A non-interconnected, dual configuration of the RCS was evaluated. This configuration, adopted tentatively, is a composite version of previously evaluated designs.

A failure-effects analysis was completed.

The command module RCS subsystems logic diagram was revised. The change involved an altered concept of the operation of stand-by solenoid valves.

Service Module

A failure mode analysis of this RCS engine is complete and is being prepared for publication.

Hardware

A reliability analysis of dual-coil compared with single-coil injector solenoid valves determined there is negligible difference between the two configurations. The single-coil valve has the advantage of a less-complex valve driver circuit.

The positive expulsion tank procurement specifications were reviewed and revised to reflect the latest reliability requirements prior to submittal to prospective suppliers.

TEST STATUS

Plume Impingement

Preparations for RCS plume impingement testing at Arnold Engineering Development Center (AEDC) continued.

Impingement plate drawings are prepared and released for fabrication. Tests of thin-plate thermocouple design have been initiated to determine response.

AEDC tests with cold gases of the same composition as the actual exhaust products have been completed. Cell pressures lower than those previously estimated were obtained. This data indicates that space conditions (approximately 250,000 feet) can be realistically simulated.

Breadboard Tests

The majority of components have been tested and accepted. Construction of the interim test facility is progressing on schedule.

Service Module

A test plan is being prepared to define a wind tunnel test that will determine the dynamic behavior of the service module RCS nozzles during simulated atmospheric flight. Aerodynamic loading on the nozzles will be determined and information will be obtained to establish vibration test requirements.

Sea-level testing of preprototype RCS engine hardware indicates that minimum impulse bits as low as 0.5 pounds per second probably can be attained on prototype hardware.

Preliminary steady-state altitude testing of preprototype service module RCS engines revealed a much lower performance than originally predicted. Various injector modifications are being tested in an effort to increase the combustion efficiency.

Materials

Measurements of the solubility of helium in nitrogen tetroxide and Aerozine 50 have been completed. The nitrogen tetroxide data have been reported, and a similar report for Aerozine 50 is being prepared. Measurement of helium solubility in monomethyl hydrazine will be initiated during the next period.

HEAT SHIELD SUBSYSTEM

REQUIREMENTS AND ANALYSIS

Thermodynamics Analysis

Data were obtained at NASA-Langley for Avcoat 5026 and phenolic nylon to be compared with the ablation test program results at Plasmadyne. The first series of arc-jet tests shows a decrease in weight loss with time.

The expected heat loads for the command module during preflight conditions were determined for an unpainted ablative surface and for a white paint surface (see Table 20).

Table 20. Heat Loads

	Summer Weather		Winter	
	normal	hot	normal	hot
Unpainted	590*	790	470	1140
Paint	380	575	**	**

* in Btu/hr
** little effect

Heat Shield Procurement

The heat shield procurement specification and work statement were revised. Program revisions resulting from the recent cost and weight reduction directives were incorporated in these documents.

DESIGN STATUS

Extensive material and thermal property tests coupled with composite panel tests indicated that a new design—using a Fiberglas honeycomb matrix bonded to the steel substructure and, subsequently, filled with Avcoat 5026-39 or LD (37 pounds per cubic foot) ablative material—is the most promising approach.

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A brazed-steel honeycomb panel was furnished to the engineering development laboratories for bonding of Fiberglas core to one face. The bonded panel will be shipped to NASA-Langley for application of their elastomeric ablative material.

The development of Avcoat 5026-39, to provide the most efficient ablator for the least weight, resulted in significant advantages in other areas. Incorporation of more phenolic micro-balloons in the Avcoat 5026-22 formulation (56 pounds per cubic foot) reduces the density, the modulus of elasticity and, most significant, the co-efficient of thermal expansion by a factor of seven. Thus, thermal stresses induced in the ablator-to-substructure bond (even at the temperature extremes of -260 to +600 F) are appreciably reduced. Another important advantage is the reduction in thermal conductivity. Fabrication procedures for production of a full-scale heat shield can be appreciably simplified by the new approach.

A modified Sylgard-182 adhesive material was developed to perform satisfactorily over the complete temperature range, -260 to +600F. Therefore, mechanical fasteners are no longer required for attachment of the ablative material to the substructure. Also, the use of 5026-39 instead of 5026-22 reduced the thermal stresses to a level well within the capability of the bond material.

RELIABILITY

Matrix test designs were formulated for the sequential ablative tests and nuclear radiation tests.

Analyses of heat ablation versus air enthalphy experimental data were completed for four materials.

In association with an experimental testing procedure, a statistical procedure was developed to derive simultaneous confidence levels of specific heat and thermal-conducting properties of Apollo ablative materials.

Development of a matrix-type test for the solar radiation tests was initiated.

Investigations were undertaken of existing nondestructive testing techniques, applicable to the evaluation of the heat shield material and its assembly to the substructure.

The study of heat-shield penetrations will continue during the next period.

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TEST STATUS

Seventeen ablative samples of Avco 5026 were instrumented with thermocouples and calorimeters for thermal tests.

The thermal-structure test of specimen A was completed; the data are being analyzed. The test setup for specimen B was initiated.

SUBCONTRACTOR ACTIVITIES – AVCO CORPORATION (HEAT SHIELD)

Avco has changed the design concept of the command module heat shield from the multiple molded tile to a filled Fiberglas honeycomb which will cover the entire structure with only three molded forms. Development testing is restricted by the lack of facilities at Avco. A facilities contract is anticipated sometime in December. Development and testing can then proceed at an accelerated pace.

[redacted]

SPACECRAFT ADAPTERS

Milestone completed during November and those scheduled for December are shown in Table 21.

FABRICATION

The adapter for mock-up 9 was completed during the last report period, and work continued on the adapters for mock-ups 11 and 18. Progress was also noted on the initial aluminum adapter 013 for boilerplate 9 as all subassemblies were completed on schedule. All of these adapters are scheduled to be completed during the next report period.

REQUIREMENTS AND ANALYSIS

Apollo Test Requirements (ATR)

The structural test requirements for ATR 401-1 were completely revised and prepared for laboratory implementation. This reevaluation was necessary because of design changes from a longeron structure with hard supports to a structure of spliced panels with a uniformly distributed load.

Boilerplates

Stress analysis work has been completed for boilerplates 6, 9, 12, 13, 15, 16, 18, 22, and 23.

Stress analysis of boilerplate 14 is 90 percent complete.

Structural Analysis

The basis of the spacecraft adapter analyses was changed. The present analysis is based on four honeycomb panels with simple sheet metal splices and no longerons. The original analysis was based on six longerons and six honeycomb panels.

Reanalysis of the test panel for ATR 401-1, which simulates one of the panels of the adapter shell, was necessary to meet the present configuration.

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Table 21. Apollo PMP Milestones

Spacecraft Adapters

Event No.	Milestone Description	Date	
		Schedule	Actual
42-045-D	Start - Adapter Drawing Release Boilerplate 14	16 Nov 62	
42-104-P	Complete - Assembly Structure Adapter Boilerplate 9	15 Dec 62	

<u>Separation System</u>

The design studies for the adapter separation system are complete.

Drawings for simulated test panels are complete. Preliminary testing has shown that charges of 15 grains/foot will cut the various thicknesses of material used in the present configuration.

DESIGN STATUS

<u>Boilerplates</u>

The last adapter change for boilerplate 6 (pad abort test article) separation system support plate is being released.

The completion of the three-way adjustable fitting change was accomplished.

The adapters of boilerplates 12, 22, and 23 have been deleted.

All scheduled adapter drawings for boilerplate 14 (house spacecraft 1) have been released.

<u>Structure</u>

Three layouts depicting the structure necessary to house the lunar excursion module in a tapered adapter have been completed.

A new up-to-date layout of the main access door was made.

The material gages in the panels and access doors will be reanalyzed. Some redesign or reduction of the gages will be necessary because pressure loads have been reduced.

An adapter panel assembly drawing has been prepared. This assembly contains the forward and aft frames and closing channels. As this drawing represents a typical assembly of the adapter structure, it will expedite the production of the remaining drawings.

The design layout of the adapter structure was redrawn to reflect the current design status of the C-1 spacecraft adapter.

TEST STATUS

Tooling has been completed and many detailed parts have been made in preparation to bond a honeycomb panel that is representative of the C-1 adapter panel configuration.

Shaped charge type explosives of various sizes have been tested on small size aluminum honeycomb panels that are similar to the C-1 adapter type of construction.

REPORT ON DELETION OF INSERTS AND ADAPTERS FROM LITTLE JOE II VEHICLES

The Little Joe II flight vehicles (boilerplate 12, 22, 23 and airframe 2) are being modified because the requirement to simulate spacecraft length has been eliminated by NASA directive. This direction was based on NASA wind tunnel test results that showed there is no aerodynamic requirement to simulate the spacecraft length in these test vehicles.

This direction resulted in a program cost savings because the change in length will be accomplished by replacing the boilerplate service module insert and adapter with a 10-inch service module extension. This extension provides for direct attachment to the Little Joe II Vehicle. In addition, airframe 2 (service module) will be changed from a spacecraft configuration to a boilerplate configuration.

[redacted]

SPACECRAFT GROUND SUPPORT EQUIPMENT

REQUIREMENTS AND ANALYSIS

Milestones completed during November and those scheduled for December are shown in Table 22.

FABRICATION

As a result of program analyses held last month, 24 models of GSE for boilerplate 6 will be fabricated by S&ID on a special priority basis. The majority of handling and auxiliary models are scheduled for completion during January, while certain complex checkout models are scheduled for completion during February. This is the first boilerplate to require GSE in large quantity and of this complexity. Maximum effort will be required by all concerned in order to meet the above completion dates. At the present time, no definite requirements have been established for spacecraft GSE.

PROVISIONING

The GSE planning and requirements document was published. This document shows GSE usage for each test vehicle.

GSE for boilerplate 6 has firm manufacturing completion dates for all but the test conductor console, C14-019. Maximum effort is being directed to assure provisioning and GSE for the scheduled test events for boilerplates 6 and 12.

The tight scheduling problems for GSE provisioning experienced to date stresses the need for expediting the Mercury/Gemini/Apollo GSE cross-utilization studies. GSE with long manufacturing lead times can cause serious test delays of Apollo test vehicles if timely identification and approval for make or buy by NASA is not received.

AUXILIARY MODEL DESIGN

During the report period, the auxiliary GSE model design for the launch escape system (LES) optical alignment was released.

Laboratory tests of the hot bridge wire (HBW) simulator unit of the pyrotechnics initiator set circuit are 75 percent complete. Parts for final

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Table 22. Apollo PMP Milestones

Command Module and Service Module Ground Support Equipment

Event No.	Milestone Description	Date Schedule	Date Actual
43-007-D	Complete - Handling GSE Design Boilerplate 3	22 Oct 62	16 Nov 62
43-008-D	Complete - Auxiliary GSE Design Boilerplate 3	22 Oct 62	20 Nov 62
43-014-D	Complete - Handling GSE Design Boilerplate 3	26 Oct 62	
43-021-D	Complete - Handling GSE Design Boilerplate 6	1 Nov 62	
43-030-D	Complete - Handling GSE Design Boilerplate 13	9 Nov 62	
43-004-D	Complete - GSE Concept Boilerplates 3 and 19	15 Nov 62	
43-020-D	Complete - GSE List Boilerplates 6, 12, 22, and 23	19 Nov 62	
43-006-D	Complete - GSE List Boilerplates 3 and 19	7 Dec 62	
43-046-D	Complete - GSE Concept Airframe 002	10 Dec 62	

Table 22. Apollo PMP Milestones

Command Module and Service Module Ground Support Equipment (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
43-025-D	Complete - Preliminary GSE Concept Boilerplates 13, 15, 16, and 18	14 Dec 62	
43-005-D	Complete - NASA Approval GSE Concept Boilerplate 3 and 19	21 Dec 62	
43-023-D	Complete - C/O GSE Design Boilerplate 6	21 Dec 62	
43-034-D	Complete - Preliminary GSE Concept Boilerplate 14	21 Dec 62	
43-015-D	Complete - Auxiliary GSE Design Boilerplate 9	22 Dec 62	
43-022-D	Complete - Auxiliary GSE Design Boilerplate 6	22 Dec 62	
43-033-D	Complete - Service GSE Design Boilerplate 13, 15, 16, and 18	28 Dec 62	
43-024-D	Complete - Service GSE Design Boilerplate 6	30 Dec 62	

[redacted]

assembly have been ordered and testing will be completed when a circuit breaker and relay have been received.

CHECKOUT

A revision was completed of the procurement specification for the telemetry ground station (Model C14-021) to provide eventual coded modulation/frequency modulation capability.

The Pratt & Whitney Aircraft fuel cell powerplant test stand (Model C14-084) underwent design changes to reduce the original cost by 62 percent. The stand is now completely manually-operated. The delivery schedule will not be affected by these design changes.

The stimuli and commands to be generated by the GSE carry-on equipment were defined as 28 stimuli and 30 commands generated by the receiver/decoder portion of the digital command system and stimuli generator.

A study has been completed to determine where the carry-on GSE can be installed during the checkout of the spacecraft. The carry-on GSE will be used during all tests performed on the command and service modules up to approximately T-4 hours. It was determined that the maximum available space under the left-hand couch is 11 cubic feet, while that under the right-hand couch is 6 cubic feet.

Checkout GSE model designs were released for the test conductor/assistant test conductor console and the electrical cable set.

During the next report period, a review will be made of telemetry ground station proposals. GSE requirements for all rocket engine subcontractors will be reevaluated to insure that adequate GSE is being provided.

HANDLING

Handling GSE model designs were released for the adapter rail transfer flow skirt, flow skirt handling ring, box level, and service module and spacecraft adapter weight and balance set.

A list was prepared of problem areas related to NASA-MIT-S&ID GSE equipment interfaces. The two main areas of principle concern are handling equipment and bench maintenance spacifications.

[redacted]

[redacted]

After reviewing the layouts of the LES weight and balance fixture (Model H14-016), it was determined that it would not be feasible to perform the required fabrication support boilerplate 6 schedules and maintain schedule requirements. A new approach was established that eliminated the optical alignment requirements and complex adjustment system of the other design. Also, this approach is much simpler to fabricate. All drawings have been completed for the new system.

SERVICING

Changes in the spacecraft system have caused a redesign of the servicing GSE for the helium booster unit, the liquid hydrogen transfer unit, and the liquid oxygen transfer unit.

SPACE

An over-all GSE system checkout block diagram based on the SPACE concept was completed.

A group of logic components was selected for use in the SPACE system breadboard test program. All selected components are readily available.

A breadboard test program is planned for an early evaluation of SPACE. Preliminary design control specification will be prepared for specific end items involved.

DESIGN

Design completion and release of the following items of GSE is planned during the next period:

Command module intermodule simulator

Launch vehicle intermodule simulator LJ-II

Auxiliary crane control (procurement specification)

Radar transponder and recovery beacon checkout unit

Explosive bridge wire firing unit bench maintenance

Launch escape system weight and balance fixture

Spacecraft weight and balance fixture

Electrical weighing kit 3000 pounds capacity procurement specification

Electrical weighing kit 30,000 pounds capacity procurement specification

Cradle transporter launch escape system

Adapter rollover

Sling, jettison motor nose cone

Ballast pickup hook

Servicing unit R & D instrumentation cooling system

SIMULATORS AND SIMULATION

SPACECRAFT

Simulator Complexes

Definitions and objectives of engineering simulator complexes 1 and 2 and engineering evaluator complexes 1, 2, and 5 were completed. All were released with the exception of those for evaluator 5 complex.

A new spacecraft simulation hardware utilization list was completed during the report period.

Visual Studies

The proposed analyzer-I interim simulation center facility and equipment requirements have been completed. Design of the docking-window display mounts for analyzer-I has started.

Ten approaches to visual display were studied and evaluated. Four approaches have been selected for application to Apollo simulation.

Schedules and basic specifications for visual tests were established.

Tests were made of a small starfield projector for use in single window studies.

During the next report period, modifications 3 and 4 of analyzer-I will be initiated to include a VERDAN computer and, eventually, a high fidelity visual display.

MISSION

Study 6.1

Part 1 of this study (attitude control dynamics) has been operating at a reduced efficiency due to continued equipment malfunction. Part 2 (pulse modulation techniques) continues on schedule.

Studies 6.2 and 6.3

Study 6.2 (orbital transition dynamics) and Study 6.3 (command module systems) have been prepared for mechanization on the analog computer.

Space Operations Simulation

The series 4 design has been frozen to complete the details before occupying the computer. Work is continuing on the mechanization of the stabilization and control system (SCS) jet select logic, simulation time clocks, digital-to-analog conversion equipment, simulation-time standard tie-in equipment, and Δ V simulation equipment. Jet select logic for full mission simulation, series 4, will be completed during the next report period.

Space Flight Phase Simulation

Series 6 preparation is continuing on schedule. Preliminary equations-of-motion, block diagrams, and mechanizations have been completed. Relevant technologies are expected to contribute to this effort by updating the system parameters incorporated in the preliminary mechanizations.

Evaluator Complex I

Modification of the command module evaluator 1 controls and displays for Phase II capability will be completed during the next report period. Also, equipment connection and checkout for Phase II capability will be completed.

Evaluator Complex II

Modification of the command module evaluator 2 controls and displays for Phase I capability will be completed during the next report period.

EQUIPMENT

The rough draft of the mission simulator trainer procurement specification was completed during the report period. To support the mission simulator trainer procurement specification, the performance criteria rough draft was completed and submitted to NASA.

Design of the three-part task trainers for the final configuration will be initiated during the next report period.

The specification for earth-launch and reentry trainer-computer procurement will be completed.

A computer procurement specification for navigation and trajectory control and orbital and rendezvous trainers will be initiated.

Mission Simulator Trainer

A review was made of the capability data received from prospective bidders for the mission simulator trainer.

The technical evaluations for the combined analog-digital computer consultant for the engineering simulation program have been completed.

FACILITIES

NASA has requested the Columbus Division of NAA to subcontract to MSC the facilities currently being used by S&ID for rendezvous-docking studies.

TRAINING AND TRAINERS

Milestones completed during November and those scheduled for December are shown in Table 23.

Four hundred and sixty-six student hours of training were accomplished during the report period.

The 1-1/2 hour Apollo familiarization lecture is being transferred to video tape. The script will be in final lecture form by January 1963.

The six-hour Apollo hardware and mission familiarization course outline was submitted to the NASA flight crew operations division for study. Included in the outline were reproductions of the training aids to be used, lesson guides keyed to the course outlines, and the Design Review Manual (AP 62-15). NASA requested and was furnished eighty-one 35mm slides selected from the course material.

The course in space science for astronauts, to be included in the training plan, has been sent to MSC for review. The course covers the following sciences:

Interplane and stellar astronomy

Space physics

Orbital mechanics

Trajectories and space navigation

Selenography

Gas dynamics

Computer technology

Table 23. Apollo PMP Milestones

Training and Trainers

Event No.	Milestone Description	Date	
		Schedule	Actual
25-040-D	Complete - Simulator Trainer Preliminary Specifications	1 Dec 62	1 Sept 62
25-041-D	Complete - Simulator Procurement Specifications	1 Dec 62	
25-013-D	Complete - Publication of Flight Operational Development Course	7 Dec 62	

INSTRUMENTATION

R & D INSTRUMENTATION

Requirements and Analysis

Milestones completed during November and those scheduled for December are shown in Table 24.

Controls and Displays

The following projects will be completed during the next report period:

1. The feasibility and working models of the entry monitor instruments

2. The controls and display clamp design for thermal and mechanical mounting

3. The mechanization of four representative subpanels of the main display console

4. All drawings required for a fully detailed mock-up of the lower equipment bay for wiring and maintenance studies

5. Preliminary design of controls and displays indication system.

The receiving inspection, calibration, and functional checkout specification for the NASA-furnished R & D instrumentation equipment.

In-Flight Test System (IFTS)

The IFTS procurement specification has been prepared; the summary report, including test points and measurement lists, was completed and submitted to NASA.

Boilerplate 6

The systems requirements—established, designed, and procured by NASA—were forwarded to S&ID for installation in the spacecraft.

The calibration and functional checkout procedures are about 85-percent completed, approved, and released. Approximately 50 percent of the

Table 24. Apollo PMP Milestones

Instrumentation

Event No.	Milestone Description	Date	
		Schedule	Actual
24-008-D	Complete - Receipt of Data on Telemetry Sub-Carrier Assembly Boilerplate 6	1 Nov 62	14 Nov 62
24-009-D	Complete - Receipt of Data on Telemetry Radio Frequency Assembly Boilerplate 6	1 Nov 62	14 Nov 62
24-010-D	Complete - Installation Design of Telemetry Measuring Equipment Boilerplate 6	1 Nov 62	14 Nov 62
24-012-D	Complete - Receipt of NASA Data on Data Storage Equipment Boilerplate 6	1 Nov 62	
24-013-D	Complete - Installation Design of Data Storage Equipment Boilerplate 6	1 Nov 62	15 Nov 62
24-015-D	Complete - Receipt of Data on Acceleration Sensors Boilerplate 6	1 Nov 62	15 Nov 62
24-019-D	Complete - Receipt of Data on Timer Boilerplate 6	1 Nov 62	15 Nov 62
24-020-D	Complete - Receipt of Data on Rate Gyro Boilerplate 6	1 Nov 62	1 Nov 62

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Table 24. Apollo PMP Milestones

Instrumentation (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
24-022-D	Complete - Installation Design of Sensor Equipment Boilerplate 6	1 Nov 62	16 Nov 62
24-030-D	Complete - Receipt of Data on Signal Conditioner Box Boilerplate 6	1 Nov 62	
24-032-D	Complete - Receipt of Data on Direct Current Amplifier Boiler-plate 6	1 Nov 62	15 Nov 62
24-033-D	Complete - Installation Design of Signal Conditioner Equipment Boilerplate 6	1 Nov 62	15 Nov 62
24-034-D	Complete - Inspection and Calibration of Instruments Boilerplate 6	1 Nov 62	
24-051-D	Complete - Receipt of Data on Acceler-ation Sensor Boilerplate 12	1 Nov 62	15 Nov 62
24-052-D	Complete - Receipt of Data on Statham Pressure Sensor Boiler-plate 12	1 Nov 62	
24-006-D	Complete - Manufacture of Q Ball Boiler-plate 6	15 Nov 62	

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Table 24. Apollo PMP Milestones

Instrumentation (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
24-043-D	Complete - Receipt of Data on Telemetry Sub-Carrier Assembly Boilerplate 12	1 Dec 62	
24-044-D	Complete - Receipt of Data on Telemetry Radio Frequency Assembly Boilerplate 12	1 Dec 62	
24-045-D	Complete - Receipt of Telemetry Data for C-Band X-Ponder Boilerplate 12	1 Dec 62	
24-054-D	Complete - Receipt of Data on Temperature Sensors Boilerplate 12	1 Dec 62	
24-056-D	Complete - Receipt of Data on Rate Gyro Boilerplate 12	1 Dec 62	
24-057-D	Complete - Receipt of Data on Attitude Gyro Boilerplate 12	1 Dec 62	
24-060-D	Complete - Receipt of Data on Power Control Box Boilerplate 12	1 Dec 62	
24-063-D	Complete - Receipt of Data on Junction Box Boilerplate 12	1 Dec 62	

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Table 24. Apollo PMP Milestones

Instrumentation (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
24-066-D	Complete - Receipt of Data on Signal Conditioner Box Boiler-plate 12	1 Dec 62	
24-068-D	Complete - Receipt of Data on Direct Current Amplifier Boiler-plate 12	1 Dec 62	
24-242-D	Complete - Control and Display Basic Procurement Specifications for Airframe 009	1 Dec 62	
24-248-D	Complete - Control and Display Requirements and Design for Airframe 011	1 Dec 62	
24-257-D	Complete - NASA Review and Approval of Requirements and Design for Mission Simulator #1	1 Dec 62	
24-273-D	Complete - NASA Review and Approval of Requirements and Design Earth Launch Re-Entry Trainer	1 Dec 62	
24-280-D	Complete - Control and Display Requirements and Design for Orbital Rendezvous Trainer	1 Dec 62	

[redacted]

Table 24. Apollo PMP Milestones
Instrumentation (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
24-281-D	Complete - NASA Review and Approval of Requirements and Design Orbital Rendezvous Trainer	1 Dec 62	
24-288-D	Complete - Control and Display Requirements and Design for Navigation Trajectory Trainer	1 Dec 62	
24-298-D	Complete - In Flight Test System Basic Procurement Specification	1 Dec 62	
24-046-D	Complete - Installation Design of Telemetry Measuring Equipment Boilerplate 12	15 Dec 62	
24-049-D	Complete - Installation Design of Date Storage Equipment Boilerplate 12	15 Dec 62	
24-055-D	Complete - Receipt of Data on Timer Boilerplate 12	15 Dec 62	
24-058-D	Complete - Installation Design of Sensor Equipment Boilerplate 12	15 Dec 62	
24-069-D	Complete - Installation Design of Signal Conditioner Equipment Boilerplate 12	15 Dec 62	

Table 24. Apollo PMP Milestones
Instrumentation (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
24-217-D	Complete - NASA Review and Approval of Requirements and Design for Airframe 001	15 Dec 62	
24-258-D	Complete - Control and Display Basic Procurement Specifications for Mission Simulator #1	15 Dec 62	
24-106-D	Complete - Boilerplate 14 Instrumentation Installation Design	18 Dec 62	

delivered NASA-furnished equipment is in process of calibration, the breadboard system checkout procedure is near completion, and the spacecraft instrumentation system checkout requirements are complete.

During the next period, the calibration of equipment and the breadboard instrumentation system functional checkout specification for boilerplate 6 will be completed. The R & D instrumentation system functional checkout requirements of installed equipment in boilerplate 6 will be revised.

Boilerplate 12

The equipment list is revised to the latest configuration.

Boilerplate 13

The equipment list is complete, and coordination with NASA for the initiation of installation design and operation has begun.

Boilerplates 6, 12, and 13

The installation design for boilerplate 6 is complete; it complies with recent NASA redirection. Installation designs for boilerplates 12 and 13 are 90-percent and 10-percent complete, respectively.

Materials

All fabrication drawings for the engineering design inspection (EDI) booth and mock-up 18 were completed. Some of these drawings are undergoing modification to reflect changes by the recent SPACE studies, changes in the navigation and guidance equipment, and changes to conform to life systems requirements.

Self-Contained Instrumented Dummy

The self-contained instrumentation package (SCIP) system analysis and preliminary design were completed. Figure 4 shows the system elements, consisting of a magnetic tape recorder (chest-installed, 3-axis rate gyro, six accelerometers) and eight strain gages (installed on the restraint harness). The battery-powered system is completely self-contained within the dummy.

Procurement, receiving inspection, calibration, and functional checkout specifications will be prepared for SCIP equipment. A tape recorder also will be selected and procured for SCIP.

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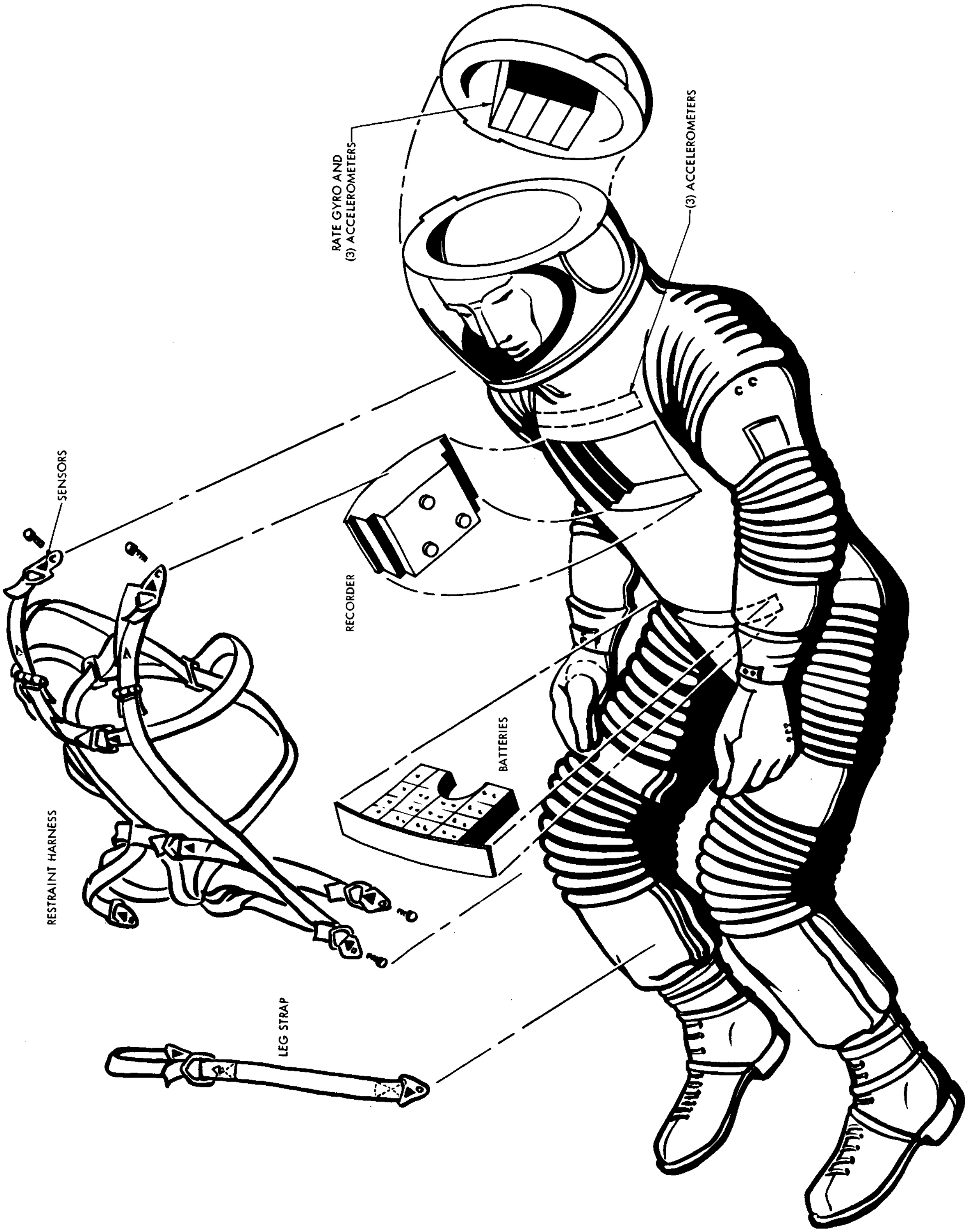

Figure 4. Instrumented Anthropomorphic Dummy

The test program is shown below:

Tests	Vehicles
Land and water impact	B1, B2, AFRM-005
Vibration qualification	AFRM-006
Crew systems qualification	AFRM-008

Launch Escape System Static Firing Test Program

A development plan of action was established and the preliminary design of the instrumentation system was completed.

Installation requirements and checkout procedures will be prepared for the LES test program during the next period.

Reliability Status

Procurement specifications were completed for the acoustic measurement system, stress measuring system, vibration measuring system, R & D antenna equipment (telemetry, C-Band), and radome.

OPERATIONAL INSTRUMENTATION

Boilerplate 14

The instrumentation equipment list for boilerplate 14 is complete. Procurement of components is in progress.

Airframes and Test Fixtures

Signal conditioner requirements, design criteria, and the division of responsibility for signal conditioner procurement have been determined for airframe 9.

The physical and functional criteria for inclusion in procurement specifications—temperature, acoustic, displacement, leak detection, acceleration, and flow transducers—have been established for airframe 9. The procurement specification for pressure transducers for this airframe is completed. The equipment list and system design criteria for airframe 1 and test fixture 2 are complete.

The physical and functional criteria for component procurement have been developed and are being included in procurement specifications. Procurement of components for airframe 1 and test fixture 2 is in progress, using "flysheet" specifications.

Radiation

A preliminary Apollo radiation instrumentation system is being evaluated. It contains the following subsystems:

1. Proton directionality detection for spacecraft orientation
2. NASA-furnished personal dosimeters
3. Early warning by reception of electromagnetic radiation

The technological status of radiation instrumentation flown on satellite or rocket flights and equipment in advanced development is being surveyed. Emphasis is placed on components that are basically off-the-shelf items.

Preliminary specifications for purchase of prototype radiation equipment, to be assembled for system tests, will be prepared during the test period. The total radiation environment for the command module both within and outside of the spacecraft will be defined.

Scientific Instrumentation

Additional data were added to the Scientific Interface Specifications (SID 62-1002) to indicate the extent of telemetry tape recorder power, location, and volume for NASA-furnished scientific instrumentation equipment.

The instrumentation system checkout procedure for boilerplate 14, airframe 1, and test fixture 2 will be released during the next period.

Cameras

Procurement specifications for the operational cameras are 90-percent complete. Camera installation design for boilerplate 14, airframe 1, and test fixture 2 has started.

The procurement specifications for camera systems will be finished, and mock-ups of camera systems will be installed in mock-up 18 during the next period.

RELIABILITY STATUS

Table 25 lists the predicted reliability of components of the instrumentation subsystem. The predicted reliability without redundancy factor is based on Minuteman generic failure rates. This data is also used for the prediction of reliability with proposed redundancies.

The apportioned reliabilities use part sensitivity indices as a basis for the apportionment. The values of apportioned reliability are based on alternate modes of operation. S&ID is conducting studies to determine the optimum number of spares for a range of electronic subsystem weights. In-flight maintenance and spares concepts generated from these studies will establish the apportioned reliability.

The critical factors are based on the partial derivative for the probability of crew safety with respect to the component. The value for the probability of crew safety used in the foregoing computation was derived from the mission phase logic diagrams.

TEST STATUS

The transducer evaluation test program is under way. Ten transducers have been received.

Table 25. Instrumentation Subsystem

Equipment	Predicted Reliability					
	$N \lambda 10^{-6}$	Time Hrs.	No Redundancy	Proposed Redundancy	Apportioned Reliability	Criticalness Factor
Central Timing*	17.693	336	0.994055	0.999994	0.9999998	0.047742
In-flight test system	128.354	336	0.995687	0.995687	0.9998	
Manual test set	7.731	33.6	0.99975	0.99975	0.99992	
TV system	23.60	30	0.99929	0.99929	0.99998	
Sensor	3.60	336	0.99879	0.99879	0.9989	
C-band antenna	0.1031	9.7	0.999999	0.999999	0.999999	0.021353
VHF recovery antenna	0.0138	72.3	0.999999	0.999999	0.999999	0.00000000014
HF recovery antenna	0.1333	7.5	0.999999	0.999999	0.999999	0.0000000863
2KMC high gain antenna	159.85	26.9	0.9957	0.9957	0.99990	0.005497
VHF recovery antenna backup	1.0	72	0.999928	0.999928	0.99999	0.0000000004
Radome	0.00003	335.7	0.99999999	0.99999999	0.99999999	

[redacted]

Table 25. Instrumentation Subsystem (Cont)

Equipment	Predicted Reliability					
	$N \lambda 10^{-6}$	Time Hrs.	No Redundancy	Proposed Redundancy	Apportioned Reliability	Criticalness Factor
Photographic					(0.9977)**	
Radiation detection					0.9995	
Controls and displays					0.9999	
TOTAL			0.9810	0.986866	(0.995593)**	
					0.997877	

*Quad Redundancy on the Part Level
**Added to equipment list after apportionment

[redacted]

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SPACECRAFT TEST OPERATIONS - Downey

Milestones completed during November and those scheduled for December are shown in Table 26.

Apollo Facilities has approved two interim work areas, A and B, in Building 1 for use by Apollo Test Operations (ATO), Downey, until the addition to Building 6 is completed. Interim area A has 4000 square feet and will be utilized for the checkout of boilerplate 6 (first pad abort article). Interim area B has an additional 8600 square feet and will be utilized for the checkout of boilerplates 9, 12, 13, 14, 15, 23, and the propulsion test fixture F-2.

A committee was formed to establish fluid requirements for the Building 6 addition. A report outlining the fluid requirements was submitted to the Apollo Engineering and Facilities groups to assist them in the planning for Building 6A.

A series of briefing charts outling the basic test philosophy of the environmental proof test program was prepared by ATO for presentation to NASA. The briefing was presented to NASA on 8 November 1962. In conjunction with the briefing, a trip was made by ATO personnel to three of the environmental chambers being considered for Apollo testing.

In compliance with a request by NASA for additional information on the work load requirements and capabilities of the Apollo data system, briefing charts were prepared by ATO data engineering. The presentation was made to representatives of NASA at Downey during the report period.

Five tests of the parachute development drop test program were accomplished during the latter part of October and early November, bringing the total of complete tests to 14. Photographs and telemetry data were acquired on each of the tests. These data are currently being reviewed by S&ID and Northrop-Ventura.

As a part of the program to gain additional facts concerning equipment for the proposed spacecraft prelaunch automatic checkout equipment (SPACE) system, several members of the ATO data engineering group made a trip to the AMR. The primary objective of the trip was to ascertain the capabilities of the SPACE system and to obtain basic familiarization with the concept.

[redacted]

Table 26. Apollo PMP Milestones

Spacecraft Test Operations - Downey

Event No.	Milestone Description	Date	
		Schedule	Actual
26-051-T	Complete - Detailed Test Plan for Boilerplate 13/SA-6	1 Nov 62	1 Nov 62
26-044-T	Complete - Detailed Test Plan for Maximum Q Abort Test of Boilerplate 23	15 Nov 62	
26-036-T	Complete - Detailed Test Plan for Max Q Abort Test of Boilerplate 12	15 Dec 62	

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An ATO r-f coordinator has been appointed and assigned the task of coordinating ATO frequency requirements and clearance procedures. A meeting was held to discuss frequency allocation and frequency clearance procedures. The NASA Resident Project Office representative will assume the dual responsibility of coordinating frequency allocations with NASA and ATO.

In support of the propulsion test site equipment acquisition, bids were received by several contractors for the closed loop TV system. These bids are currently being reviewed.

A joint ATO engineering group visited NASA on 8 and 9 November 1962 to present a status report on the master measurement list and calibration data program. ATO representatives were asked to attend and to supply technical details as required to support the engineering presentation.

A specification covering the data acquisition system for the propulsion development facility was released to several contractors for quotations.

During the next report period, the frequency clearance procedures to be used at Downey during spacecraft checkout operations will be issued. In conjunction with the procedures, the frequency assignments will also be made, pending information from NASA.

Coordination with NASA concerning the definition of the environmental proof test program scope and test site will be continued. Additional detailed program planning will be required in conjunction with these negotiations.

The data reduction support of the Northrop-Ventura parachute development program will continue.

Liaison will be established with the successful bidder on the data acquisition system for the propulsion development facility. This action will be accomplished after NASA approval.

Revisions to the house spacecraft program plan are being prepared, and the joint ATO engineering approved document will be issued on or before 1 January 1963.

Checkout procedures for the telemetry system GSE are being prepared and will be released by 15 December 1962.

The preliminary measurement list for house spacecraft 1 (boilerplate 14) is in the initial planning stages. This effort is being coordinated with Engineering and is tentatively scheduled for release during January 1963.

[redacted]

PRELAUNCH AND LAUNCH OPERATIONS - AMR

The monitor and control function requirements for the checkout and launch operations of boilerplate 13 were determined. These requirements are to be utilized in establishing the umbilical loading requirements for boilerplate 13.

The AMR unit, in conjunction with Apollo Engineering, is conducting a study to determine systems required to support either a manual suborbital flight or earth-orbital flight and to delineate systems considered by S&ID to be flight safety items.

The ATO interim facility requirements for AMR were modified to reflect the change in scope of field activities. Hangar D prints were red-lined to show proposed changes in the area. Preliminary copies of these data were forwarded to Facility engineering and to the ATO-AMR field office for preliminary coordination with NASA.

Facility requirements were prepared in accordance with NASA requirements for separate environmental control system and reaction control system remote test areas. These requirements were forwarded to Facilities engineering and to the ATO-AMR field office.

A concept of operations for AMR Apollo test activities, including organization and manning levels, is in process of preparation and will be completed during the next report period.

Work is continuing on the revision to the program requirements document, which was submitted to NASA on 22 October 1962. A working level review of this document with NASA has been requested. Completion date for the next revision is December 1962. This document specifies all support required at AMR for the Apollo test program.

The facilities requirement for the Merrit Island facilities will be revised during December to reflect S&ID test requirements for the various remote areas. The facilities requiring further work are the vacuum chamber and the static firing area.

The revised detailed test plan for boilerplate 13 was completed for submission to NASA. Updating of this document will be continued during the next month.

Effort is being expended by the ATO organization in the preparation of operation test procedures for checkout of Apollo systems.

The second operational review meeting with S&ID and NASA was conducted on 7 November 1962. The AMR, WSMR, and Downey status was presented, and ATO engineering relationships were discussed. Also presented was the status of data acquisition stations at Building 6A, WSMR, and AMR, and the data reduction station at Downey.

The General Test Plan, SID 62-109, is being revised in accordance with a request from NASA. The review of the revised issue is scheduled for 3 December at NASA-MSC.

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SPACECRAFT TEST OPERATIONS - WSMR

The preliminary draft of the detailed test plan for boilerplate 12 in mission directive format was submitted for NASA review.

An ATO liaison office has been established at White Sands Missile Range (WSMR).

A revised edition of Requirement for Work and Resources (RFWAR), dated 15 November 1962, has been submitted to interested departments for comment. This document contains a detailed breakdown of the support that WSMR must furnish for the mission abort test program.

The logic network for boilerplates 22 and 23 PERT charts has been finalized.

The relationship of testing to be performed with the F-1, F-2, and F-3 test fixtures has been established. The propulsion system design group is preparing a summarization of the test requirements for each program.

ATO personnel convened with the Apollo Facilities and NASA/WSMR personnel at WSMR to review the facilities document, appendix A, for funding approval. Facility criteria were generally agreed upon. ATO has resubmitted the fluids and gas storage requirements. The cafeteria and administration buildings are being redesigned for an increase in capacity.

During the next report period, revision of the mission directive for boilerplate 12 will be completed.

The checkout of the research and development telemetry system and the Chrysler checkout equipment for boilerplate 6 will be completed at Houston within the next reporting period. ATO representatives will continue their direct support of these checkouts.

ATO, in conjunction with Apollo Engineering, will finalize the GSE concept and requirements.

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FACILITIES

REQUIREMENTS AND ANALYSIS

Milestones completed during November and those scheduled for December are shown in Table 27.

PROGRAM MANAGEMENT AND ENGINEERING

The Apollo operations center was completed 13 November on schedule for the NASA briefing.

The Apollo Logistics Department was relocated to Building 3.

Apollo flight performance personnel were moved from Building 6 to Zone 7 of Building 1.

Most of the Apollo Engineering group will be rearranged before the end of the year to allow adequate space for future growth.

The balance of the rearrangements of Apollo program management in Zone 15 and 23 of Building 1 will be completed in December.

Further improvements in the Apollo operations center will be continued during the next report period.

SUBCONTRACTOR COORDINATION

The El Centro facilities rehabilitation responsibility was transferred from Northrop-Ventura to S&ID. This includes the balance of design, preparation of bid package, award of contract, and inspection and acceptance of construction. A new facilities appendix for the Northrop-Ventura El Centro facilities was prepared and NASA approval obtained.

The appendix for El Centro is expected to be funded with immediate funding provided in the amount of $20,000 for parachute tables and architectural and engineering services.

The appendix for Beech Aircraft Company facilities will be submitted to NASA during the next report period.

[redacted]

Table 27. Apollo PMP Milestones

Facilities

Event No.	Milestone Description	Date	
		Schedule	Actual
46-120-F	Complete - Propulsion Systems Development Facility A & E Design Development	1 Oct 62	
46-055-F	Complete - Systems Integration and Checkout Facility Structural Steel Design	5 Oct 62	
46-121-F	Complete - MSC Approval of Propulsion Systems Development Facility A & E Design	11 Oct 62	
46-051-F	Complete - MSC Approval of A & E Design of Systems Integration and Checkout Facility Site and Foundation	15 Oct 62	
46-056-F	Complete - MSC Approval of System Integration and Checkout Facility Structural Steel Design	15 Oct 62	
46-114-F	Complete - Award of Impact Test Facility Construction Contract	17 Oct 62	
46-115-F	Start - Impact Test Facility Construction	20 Oct 62	
46-004-F	Complete - Award of Data Ground Station A & E Contract	24 Oct 62	

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Table 27. Apollo PMP Milestones

Facilities (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
46-072-F	Complete - Award of Space Systems Development Facility Environmental Control Building A & E Contract	27 Oct 62	
46-081-F	Complete - Award of Space Systems Development Facility Reaction Control	27 Oct 62	
46-090-F	Complete - Award of Space Systems Development Facility A & E Contract	27 Oct 62	
46-068-F	Complete - Systems Integration and Checkout Facility Construction	29 Oct 62	
46-033-F	Complete - Award of Plaster Master Facility Construction Contract	1 Nov 62	
46-017-F	Complete - MSC Approval of Bonding and Test Facility A & E Design	3 Nov 62	
46-034-F	Start - Plaster Master Facility Construction	7 Nov 62	
46-116-F	Start - Impact Test Facility Structural Steel Erection	9 Nov 62	
46-129-F	Complete - MSC Approval of A & E Design of Propulsion Systems Development Facility Service Module Test Stand Complex	9 Nov 62	

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Table 27. Apollo PMP Milestones

Facilities (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
46-042-F	Complete - Award of Radiographic Facility Construction Contract	10 Nov 62	
46-043-F	Start - Radiographic Facility Construction	17 Nov 62	
46-122-F	Complete - Award A & E Contract for Design of Propulsion Systems Development	23 Nov 62	
46-148-F	Complete - MSC Approval of Propulsion Systems Development Facility Combined Systems Test Stand Complex	23 Nov 62	
46-060-F	Complete - Systems Integration and Checkout Facility A & E Design	30 Nov 62	
46-117-P	Complete - Impact Test Facility Structural Steel Erection	2 Dec 62	
46-052-P	Complete - Award of Systems Integration and C/O Site and Foundation Construction Contract	5 Dec 62	
46-057-P	Complete - Award of Systems Integration and C/O Structural Steel Construction Contract	5 Dec 62	
46-061-P	Complete - MSC Approval of Systems Integration and Checkout Facility A & E Design	10 Dec 62	

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Table 27. Apollo PMP Milestones

Facilities (Cont)

Event No.	Milestone Description	Date Schedule	Date Actual
46-099-P	Complete - A & E Design of Space Systems Development Facility Structural Steel	10 Dec 62	
46-009-P	Complete - Data Ground Station A & E Design	12 Dec 62	
46-053-P	Start - Systems Integration and Checkout Facility Site And Foundation Construction	12 Dec 62	
46-118-P	Complete - Impact Test Facility Construction - Beneficial Occupancy Date	12 Dec 62	
46-095-P	Complete - A & E Design of Space Systems Development Facility Site Preparation and Foundation	15 Dec 62	
46-100-P	Complete - MSC Approval of Space Systems Development Facility Structural Steel Design	20 Dec 62	
46-134-P	Complete - Award A & E Contract For Design of Propulsion System Development Facility Combined System Test	20 Dec 62	
46-146-P	Complete - Award A & E Contract For Design of Propulsion System Development Facility Combined System Test	20 Dec 62	

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Table 27. Apollo PMP Milestones

Facilities (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
46-148-P	Complete - MSC Approval of Propulsion Systems Development Facility Combined System Test Stand Complex	20 Dec 62	
46-006-P	Complete - MSC Approval of Data Ground Station A & E Design	22 Dec 62	
46-018-P	Complete - Award of Bonding and Test Facility Construction Contract	23 Dec 62	
46-082-P	Complete - A & E Design of Space Systems Development Facility Reaction Control Building	24 Dec 62	
46-123-P	Complete - A & E Design of Propulsion Systems Development Facility Site	25 Dec 62	
46-096-P	Complete - MSC Approval of A & E Design of SSDF Site Preparation & Foundation	26 Dec 62	
46-035-P	Complete - Plaster Master Facility Building	28 Dec 62	
46-019-P	Start - Bonding and Test Facility Construction	30 Dec 62	
46-020-P	Complete - Bonding and Test Facility Site Preparation	30 Dec 62	

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Table 27. Apollo PMP Milestones

Facilities (Cont)

Event No.	Milestone Description	Date	
		Schedule	Actual
46-044-P	Complete - Radiographic Facility Building Shell	31 Dec 62	
46-073-P	Complete - A & E Design of Space Systems Development Facility Environmental Control Building	31 Dec 62	

PLANT LAYOUT AND AREA PLANNING

Revised area layouts for Apollo Engineering relocations have been completed. The Apollo Material group has been relocated from Building 11 to Zone 15 in Building 1. This move consolidates the entire material group within the area.

The engineering development inspection will take place in Building 4 during December.

MANUFACTURING SUPPORT

A formal technical review with NASA on the space systems development facility (SSDF) was held on 7 November. Further justification for certain SSDF test areas was submitted to NASA on 21 November. Approval and design initiation are expected during the report period.

A technical review was held by NASA on the Apollo test requirements (ATR) and the special test equipment systems to support ATR. NASA concurred with the requirements for seven special test equipment systems, with the approximate value of $2,225,000. It should be noted that concurrence was for requirement only and not necessarily for funding classification approval. Further tentative NASA approval of 11 additional special test equipment systems has been made as to requirement. On Monday, 26 November, two additional special test equipment systems were reviewed with NASA for technical approval, with the approximate value of $750,000.

Preparations are in progress to provide the necessary back-up material to substantiate the cost proposal items within the Apollo Facilities scope. Initial meetings with NASA representatives have begun.

FACILITIES PROJECTS

Construction of additional parking facilities at Downey was begun during the report period. Work is progressing on schedule.

Revised design criteria for the space systems development facility incorporating changes in building configuration was transmitted to NASA on 21 November.

Appendix A, Volume I, for the propulsion systems development facility, Las Cruces, New Mexico, was submitted and reviewed with the NASA-WSMR resident manager. Conditional approval was obtained pending minor revisions.

A contract for architectural services and engineering design of the space systems development facility should be let during the next report period.

The plaster master facility construction contract is scheduled for award by 10 December.

The impact test facility construction contract should be let early in the next report period.

APOLLO FACILITIES STAFF

A systematic procedure for reporting construction contractors' progress as related to PERT networks has been established. The resultant information will be utilized to support biweekly TWX reporting requirements.

A meeting was held with the general contractor on the impact test facility. The purpose of this meeting was to revise the PERT network to reflect the contractor's plan for a 65-day construction period. The revised network has been completed pending general contractor approval.

[illegible]

DOCUMENTATION

The following S&ID documents were published during the month of November:

SID No.	Title
62-1001	Research and Development Flight Instrumentation Interface Requirements Specification
62-1002	Scientific Instrumentation Interface Requirements Specification
62-7021	Apollo Support Plan
62-7022	Apollo Maintenance Plan
62-703-1	Government Furnished Property Requirements
62-703-2	Government Furnished Airborne Equipment Requirements
62-1014-2	Hardware Definitions
62-300-7	Monthly Progress Reports
62-812-2	Radiation Shielding Status Report
62-103	Structural Analysis of 0.055 Scale Apollo Wind Tunnel Models
62-251	Structural Analysis of the 0.02 Scale Apollo Wind Tunnel Models (FS-1, PS-1)
62-330	Structural Analysis of the 0.02 Scale Apollo Heat Transfer Model (H-1)
62-331	Structural Analysis of the 0.04 Scale Apollo Wind Tunnel Models (FS-4, PS-4)
62-338	Structural Analysis of the 0.03 Scale Apollo Dynamic Stability Model (FD-1)

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SID No.	Title
62-601	Wind Tunnel Test of the 0.105 Scale Apollo Module
62-669	Test and Model Information for Wind Tunnel Tests of a 0.02 Scale Force Model (SSL-1) in the Apollo in the NACAL Wind Tunnel
62-673-1	Structural Analysis of the 0.02 Scale FSL-1 Model TWT Wind Tunnel Test
62-993	Data Report for Apollo Heat Transfer Model H2 Wind Tunnel Test AEDC
62-1043	Structural Analysis of the Apollo 0.085 Scale FSJ-1 Force Model
62-1129	Data Report for Apollo Model (FS-9) in the NAAL Wind Tunnel (NAAL 487)
62-1137	Data Report for Apollo Model PS-3 Wind Tunnel Test in Tunnels A and B of the AEDC Von Karman Gas Dynamics Facility
62-1151	Preliminary Report of Transient Pressures Measured on the 0.055 Scale Apollo Pressure Model (PST-1) in NAA Trisonic Wind Tunnel
62-1212	Data Report for the Apollo Model SS-2 in the NAA Trisonic Wind Tunnel (TWT-80)
62-1214	Pretest Report for the 0.045 Scale Apollo Heat Transfer Models H-2, H-L1 in the AEDC-DRF Hypersonic Tunnels B & C
62-1256	Data Report for the Apollo Model FS-1 L-D Improvement Test
62-1299	Pretest for Tests of Apollo SD-3 Dynamic Stability Models in the AED VKF A and C Wind Tunnels
62-1316	Pressure Distribution Data Report for the Apollo Model PS-1 Wind Tunnel Test
62-557-3	Quarterly Reliability Status Report

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SID No.	Title
62-784	Qualification Status List
62-400-402	Still Photographs
62-378-391	Still Photographs
62-392-399	Still Photographs
62-403-420	Still Photographs
62-421-434	Still Photographs
62-435-442	Still Photographs
62-367-8	Motion Picture Photography
62-367-9	Motion Picture Photography
62-367-10	Motion Picture Photography
62-367-11	Motion Picture Photography
62-367-12	Motion Picture Photography
62-102	Manufacturing Plan
62-99-9	Monthly Weight and Balance Report
62-384-16	Drawing List
62-384-17	Drawing List

MANUALS

The Apollo Support Plan and Apollo Maintenance Plan were revised and reissued during the report period.

SID 62-1227, Ground Support Equipment Provisioning Procedure, has been published. Distribution is being withheld pending NASA approval.

SMA2A-06, the Integrated Spacecraft/Little Joe II Launch Operations Manual, is being delayed by a lack of inputs from the Little Joe II contractor. Intensive coordination effort is immediately required to assure completion of this document prior to the test event.

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MOTION PICTURES

S&ID photographic crews covered wind tunnel testing at Langley Research Center. Also covered were the force, pressure, and heat transfer tests of modules of the command module conducted in the 48-inch hypersonic shock tunnel at Cornell Aeronautical Laboratories.

Simulated docking studies at the North American Columbus Division were photographed under the supervision of a S&ID writer-director.

The following motion picture documentation was forwarded to NASA:

1. Transmittal No. 9 from Minneapolis-Honeywell, "Automatic Initial Stabilization of the Apollo Spacecraft"

2. Transmittal No. 10 from Lockheed Aircraft, "Propellant Launch Motor and Pitch Control Motor for the Apollo Spacecraft"

STILL PHOTOGRAPHY

Transmittals 11, 12, and 13 covering a wide cross-section of Apollo activities were forwarded to NASA. These photographs illustrated activities at Collins Radio, Pratt & Whitney, Thiokol, AiResearch, Marquardt and Northrop-Ventura.

SYSTEM CHECKOUT MANUAL CONCEPT

The revised maintenance and checkout concept requires the use of Combined Systems Test Units (CSTU) to replace certain previously identified items of simulator and checkout equipments. The CSTU's perform the same functions as SPACE equipments, but will be used only for factory and field assembly checkouts and not for the launch facility area.

The companion equipment to CSTU's will be Bench Maintenance Equipment (BME). The BME will be provided for test and checkout of individual systems down to "black box" level.

The effect of the foregoing is to eliminate the requirement that subcontractors provide a system checkout manual for their product. The subcontractors will, however, be required to furnish technical data for S&ID-produced CSTU manuals.

As a result of this concept documentation manuals by the subcontractors are eliminated and the manual-writing effort by S&ID in compiling the various CSTU's is increased. This should substantially reduce manual costs. Also, the resultant standardization of writing style will promote easier comprehension by astronauts and technicians.

APPENDIX A

S&ID APOLLO MEETINGS AND TRIPS, NOVEMBER 1962

[redacted]

Table A-1. S&ID Apollo Meetings and Trips, November 1962

Topic	Location	Date	S&ID Representative	Organization
GSE design coordination	Tulsa, Oklahoma	1-3 November	Pomykata	S&ID, NAA-Tulsa
Requirements meeting	Azusa, California	2 November	Madison, Paden,	S&ID, Aerojet-General
Contracts discussion	Burbank, California	2 November	Myers	S&ID, Lockheed
Specifications meeting	Downey, California	2 November	Carter, Bowman	S&ID, Beech Aircraft Corporation
Procedures and standard cells meeting	Boulder, Colorado	2-5 November	Salavador	S&ID, National Burea of Standards
Fuel cell and test equipment meeting	Hartford, Connecticut	2-6 November	Barnett	S&ID, Pratt & Whitney
Monthly coordination meeting	Cedar Rapids, Iowa	3-7 November	Berkemeyer	S&ID, Collins
Crew systems meeting	Houston, Texas	4 November	DeWitt	S&ID, NASA
Expulsion tanks meeting	Downey, California	4 November	Brandt, Fulton, Hershkowitz, White Bennington, Oppenheim	S&ID, Bell Aerosystems
Bioinstrumentation meeting	Chicago, Illinois Houston, Texas	4-5 November	Steinmetz	S&ID, NASA
Centrifuge run	Johnsville, Pennsylvania	4-6 November	Oliver	S&ID, Aero Medical Lab
Temporary engineering representative	Hartford, Connecticut	4-8 November	Snyder	S&ID, Pratt & Whitney

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Table A-1. S&ID Apollo Meetings and Trips, November 1962 (Cont)

Topic	Location	Date	S&ID Representative	Organization
Facility survey	Highston, New Jersey Soyaset Long Island, New York Ithica, New York Rolling Meadows, Illinois	4-9 November	Carter, Cason, Anderson, Henrichs	S&ID, RCA S&ID, Fairchild Camera S&ID, General Electric S&ID, Elgin
Simulation coordination studies	Columbus, Ohio	4-13 November	Porter, Cauchon	S&ID, NAA-Columbus
Wind tunnel tests	Hampton, Virginia	4-24 November	Daileda	S&ID, Langley Research Center
Requirements meeting	Downey, California	5-6 November	Griffith-Jones, Ahern, Martin	S&ID, Major Suppliers, Q. A. representative
Electrical panel meeting	Houston, Texas	5-6 November	Dwinell, Kronsberg, Cureton, DeWitt	S&ID, NASA
Flight table demonstration	Menlo Park, California	5-6 November	Jandrasi, Weir	S&ID, Carco Electronics
Interface studies	Cedar Rapids, Iowa	5-7 November	Percy	S&ID, Collins
Material meeting	Dayton, Ohio Latrobe, Pennsylvania	5-8 November	Krainess	Symposium
Wind tunnel tests	Pasadena, California	6-7 November	Davis	S&ID, Jet Propulsion Lab
Equipment installation	St. Louis, Missouri	6-7 November	Mayes	S&ID, McDonnell
Confinement studies	Long Island, New York	6-8 November	Oliver	S&ID, Republic Aviation

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Table A-1. S&ID Apollo Meetings and Trips, November 1962 (Cont)

Topic	Location	Date	S&ID Representative	Organization
Coordination meeting	Cambridge, Massachusetts	6-11 November	Allen, Beck, Johnson, Dunage, Todd, Berry	S&ID, NASA, MIT
GSE coordination	Minneapolis, Minnesota	6-11 November	Gibson, Garcia, Fritzinger	S&ID, Minneapolis-Honeywell
Docking simulation coordination	Columbus, Ohio	6 November 3 December	Bohlen, Patton, Krimgold	S&ID, NAA-Columbus
Operations review	Downey, California	7 November	Pearce	S&ID, NASA
Subscale test program liaison	Tullahoma, Tennessee	7 November	Nakamura	S&ID, AEDC
Communications and electrical systems meeting	Houston, Texas	7-9 November	Pope	S&ID, NASA
Environmental proof program briefing	Houston, Texas	7-9 November	Overman, Sheere	S&ID, NASA
GSE approval	Houston, Texas	7-9 November	Artz, Triman, Lindley, Howard	S&ID, NASA
Measurement list and calibration test	Houston, Texas	7-9 November	Charnack, Echmeir	S&ID, NASA
Engineering representative	Wilmington, Massachusetts	7-16 November	Mathews	S&ID, Avco
Program management review	Downey, California	8 November	Paup	S&ID, NASA
Torso dummy return	El Centro, California	8 November	Carnes	S&ID, Joint Parachute Test Facility
Heat transfer test	Minneapolis, Minnesota Tullahoma, Tennessee	8 November	Biss	S&ID, Fluidyne Corporation S&ID, AEDC
Radiator coating tests	Mountain View, California Sunnyvale, California	8 November	Woody	S&ID, Ames S&ID, Lockheed

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Table A-1. S&ID Apollo Meetings and Trips, November 1962 (Cont)

Topic	Location	Date	S&ID Representative	Organization
New England psychological association vision discussion	Boston, Massachusetts	8-9 November	Beam	Symposium
Integration coordination	Houston, Texas	8-21 November	Wilkens	S&ID, NASA
Simulation facilities meeting	Columbus, Ohio	9-13 November	Chapman	S&ID, NAA-Columbus
Temporary resident engineer	East Harford, Connecticut Hampton, Virginia	9-15 November	Shelly	S&ID, Pratt & Whitney S&ID, Hastings Raydist
Field analysis	Cedar Rapids, Iowa	11 November	Hagelberg	S&ID, NASA, Collins
Field analysis	Joplin, Missouri	11-13 November	Tapper, Otzinger	S&ID, Eagle-Picher
Cost reduction meeting	Cedar Rapids,Iowa	11-14 November	Albinger	S&ID, Collins
Progress coordination	Middleton, Ohio	11-14 November	Perry, Smith	S&ID, Aeronca
Docking simulation coordination	Columbus, Ohio	11-21 November	Oglevie, Hedvig, Dunage, Johnson	S&ID, NAA-Columbus
Wind tunnel tests	Tullahoma, Tennessee	11 November 7 December	Pagaza	S&ID, AEDC
Facilities meeting	Downey, California	12 November	Beatty	S&ID, Northrup-Ventura
Design review	Tulsa, Oklahoma	12-13 November	Palmer, Robertson	S&ID, NAA-Tulsa
Simulation discussion	Houston, Texas	12-14 November	Palmer, Marshall, Wall, Cross, Gildea, Schiffman	S&ID, NASA
Instrumentation checkout	Houston, Texas	12-21 November	Dunham	S&ID, NASA
Vendor evaluation	Phoenix, Arizona	13 November	Cason	S&ID, Motorola
Biweekly flight technology meeting	Houston, Texas	13-15 November	Stazer, Kinsler, Harthum, Bever	S&ID, NASA

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Table A-1. S&ID Apollo Meetings and Trips, November 1962 (Cont)

Topic	Location	Date	S&ID Representative	Organization
Technical conference	Huntsville, Alabama	13-15 November	Stone, Lindsay, Dupaquier, Hochman	S&ID, NASA
Communications coordination	Ft. Mayes, Indiana	13-16 November	Atlas	S&ID, ITT Kellogg, Inc.
Hot jet tests	Hampton, Virginia	13-30 November	Daileda, Lundy	S&ID, Langley Research Center
Program review	Downey, California	14 November	Storms	S&ID, NASA
Biweekly mechanical systems meeting	Houston, Texas	14-15 November	Johnson, Sweet	S&ID, NASA
Radiation effects meeting	Houston, Texas	14-15 November	Clark, Chinn	S&ID, NASA
Coordination meeting	Boulder, Colorado	14-16 November	Bouman	S&ID, NASA, Beech Aircraft
Mission simulator discussion	Houston, Texas	14-16 November	McIntryre, Mathews	S&ID, NASA
Gantry drawings review	White Sands, New Mexico	14-16 November	Rogers, Ginley	S&ID, NASA
Quarterly briefing	Downey, California	14-17 November	Reed	S&ID, Thiokol
Scene generation and projection meeting	New York City, New York Wyanddanch, New York	14-17 November	Hart	S&ID, Farrend Optical TWT Co. S&ID, Fairchild Stratos Corporation
Shielding research discussion	Catlinburg, Tennessee	14-18 November	Edgerley, Kinsler	Symposium
Program planning meeting	Houston, Texas	15-16 November	Perkins	S&ID, NASA
Specifications briefing	Houston, Texas	15-17 November	Ryker, Jacobson, Jacobson, Feltz	S&ID, NASA

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Table A-1. S&ID Apollo Meetings and Trips, November 1962 (Cont)

Topic	Location	Date	S&ID Representative	Organization
Subcontractor coordination	Minneapolis, Minnesota	15-17 November	Klein, Tutt, Barnett	S&ID, Minneapolis-Honeywell
Contract coordination	Houston, Texas	17 November	Paup, Feltz, Carroll, Ryker, Blue, Nelson, Berry	S&ID, NASA
Biweekly crew systems meeting	Houston, Texas	18 November	DeWitt, Ross, Reithmaier, Madden	S&ID, NASA
Facilities review	Houston, Texas	18 November	Dieterle	S&ID, NASA
Temporary technical representative	East Hartford, Connecticut	18-21 November	Anderson	S&ID, Pratt & Whitney
Flight dynamics meeting	Houston, Texas Huntsville, Alabama	18-21 November	Tutt, Dodds	S&ID, NASA
Specifications discussion	Downey, California	19 November	Reed	S&ID, Westinghouse
Design review	St. Louis, Missouri	19-20 November	Fentress, Divvens	S&ID, McDonnell
Simulator briefing	Houston, Texas	19-21 November	LaFance, Mathews, Hatcher, Neff, Finley	S&ID, NASA
Parachute drop tests	El Centro, California	19 November 17 December	Ellis	S&ID, 6511th Test Group
Optical coating investigation	Santa Rosa, California	20-21 November	Chinn, Carney	S&ID, Optical Coating Lab
Thrust vector alignment meeting	Tullahoma, Tennessee	20-22 November	Field, Greco, Cadwell	S&ID, AEDC
Interface meeting	San Diego, California	21 November	Gately	S&ID, Convair
Cartridge specification discussion	Houston, Texas	22-29 November	Holloway	S&ID, NASA

[redacted]

Table A-1. S&ID Apollo Meetings and Trips, November 1962 (Cont)

Topic	Location	Date	S&ID Representative	Organization
Entry discussion	Houston, Texas	25-26 November	Klein	S&ID, NASA
Hot jet tests	Hampton, Virginia	25-30 November	Lundy	S&ID, Langley Research Center
Heat transfer tests	Tullahoma, Tennessee	25-30 November	Biss, Emerson, Clemmer	S&ID, AEDC
Integration coordination	Houston, Texas	25 November 7 December	Zulka	S&ID, NASA
Vendor evaluation	Davenport, Iowa St. Louis, Missouri	26-27 November	Perkins, Cason	S&ID, Bendix, Pioneer S&ID, McDonnell
Field analysis	Hartford, Connecticut	26-27 November	Symons, Barker	S&ID, Pratt & Whitney
LES impact areas discussion	Houston, Texas	26-27 November	Dodds	S&ID, NASA
Flight technology meeting	Houston, Texas	26-28 November	Dudek, Barnett, Bornemann	S&ID, NASA
Field analysis	Los Angeles, California	26-28 November	Reilly	S&ID, AiResearch
Engineering coordination	Elkton, Maryland	26-29 November	Bergeron	S&ID, Thiokol
Temporary resident engineer	Hartford, Connecticut	26-30 November	Synder, Brown, Nash	S&ID, Pratt & Whitney
Powers systems meeting	Houston, Texas	27-28 November	Simkin, Cash, Eldridge, Gibb	S&ID, NASA
Design review	Tulsa, Oklahoma	27-29 November	Robertson, Palmer, Lambert	S&ID, NAA-Tulsa
Navigation and guidance meeting	Cambridge, Massachusetts	28-29 November	Louie, McAllister	S&ID, MIT
Preaward survey	Dallas, Texas	28-29 November	Anderson, Dorsett, Perkins	S&ID, Texas Instruments

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Table A-1. S&ID Apollo Meetings and Trips, November 1962 (Cont)

Topic	Location	Date	S&ID Representative	Organization
Monthly guidance and control meeting	Houston, Texas	28-29 November	Steiner, Martin, Kennedy	S&ID, NASA
Fuel cell discussion	East Hartford, Connecticut	28-30 November	Champaign	S&ID, Pratt & Whitney
Hot wire initiator discussion	Houston, Texas	28-30 November	Johannes, Holloway	S&ID, NASA
Statement of work resolution	Downey, California	28-30 November	Stady	S&ID, MIT
Human factors meeting	New York City, New York	28 November 1 December	Rabideau	S&ID, Electronics Industries Association
Life systems coordination	Houston, Texas	29-30 November	Wingo	S&ID, NASA
Heat shield meeting	Valley Forge, Pennsylvania	29-30 November	Hogenson	S&ID, General Electric
Interchange and heat shield meeting	Wilmington, Massachusetts	29 November	Augustus, Taylor Confer, Morant, King	S&ID, NASA

APPENDIX B

APOLLO MASTER DEVELOPMENT SCHEDULE

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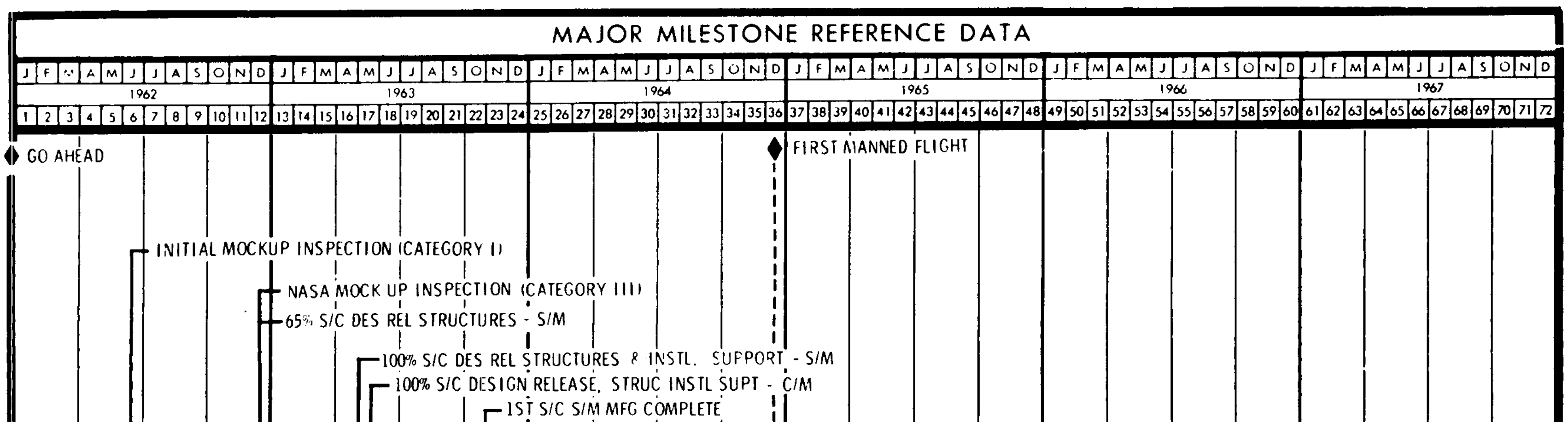
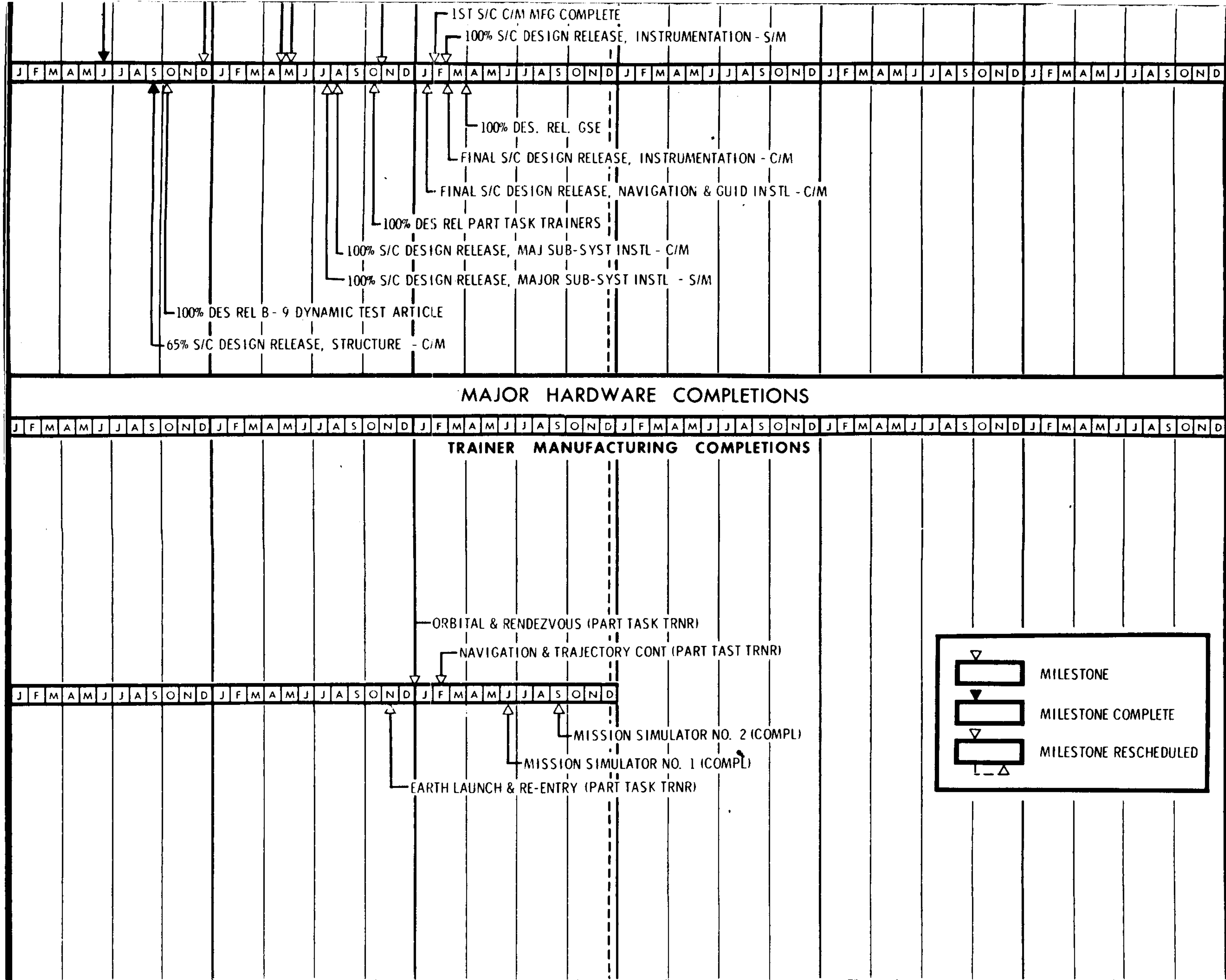
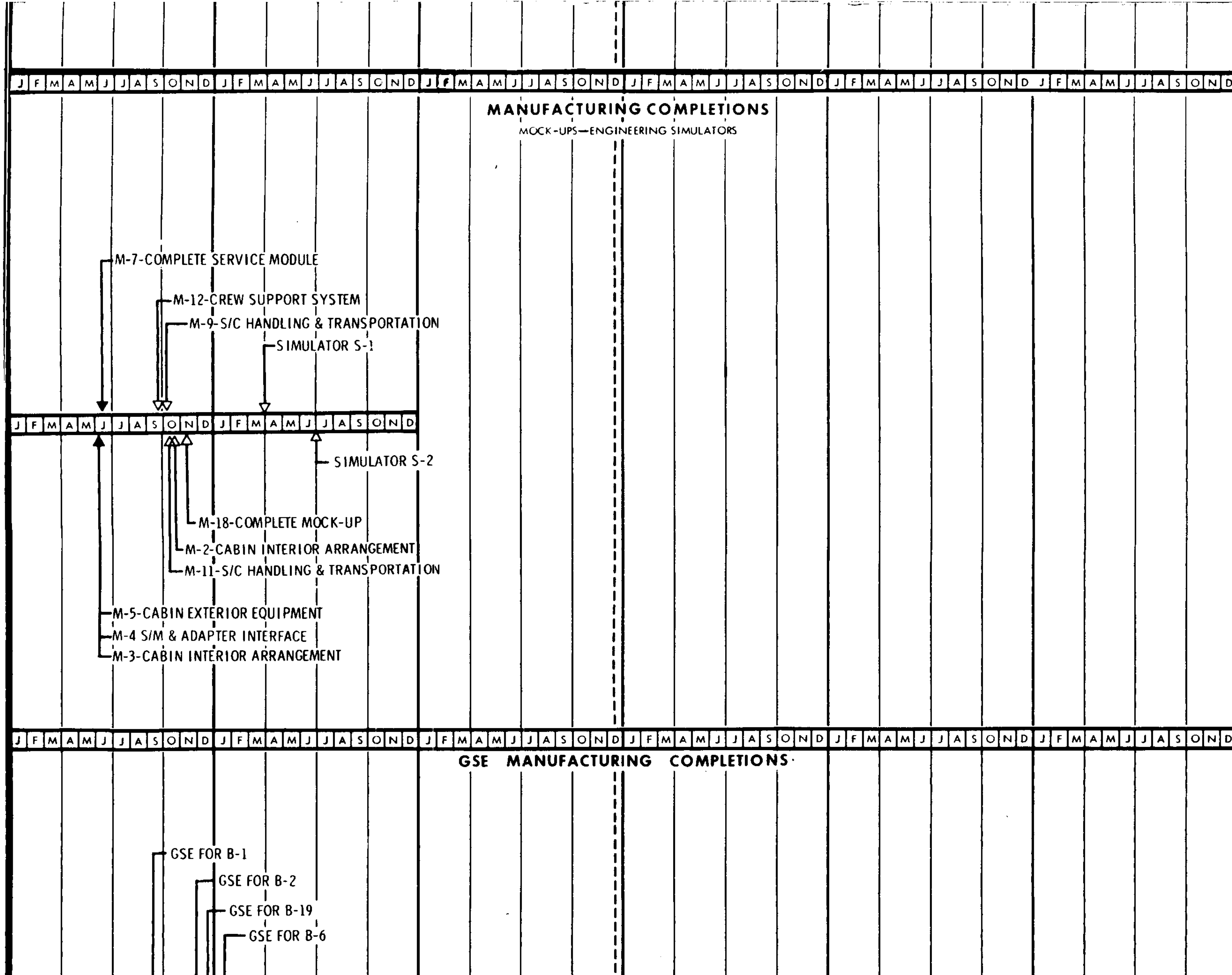
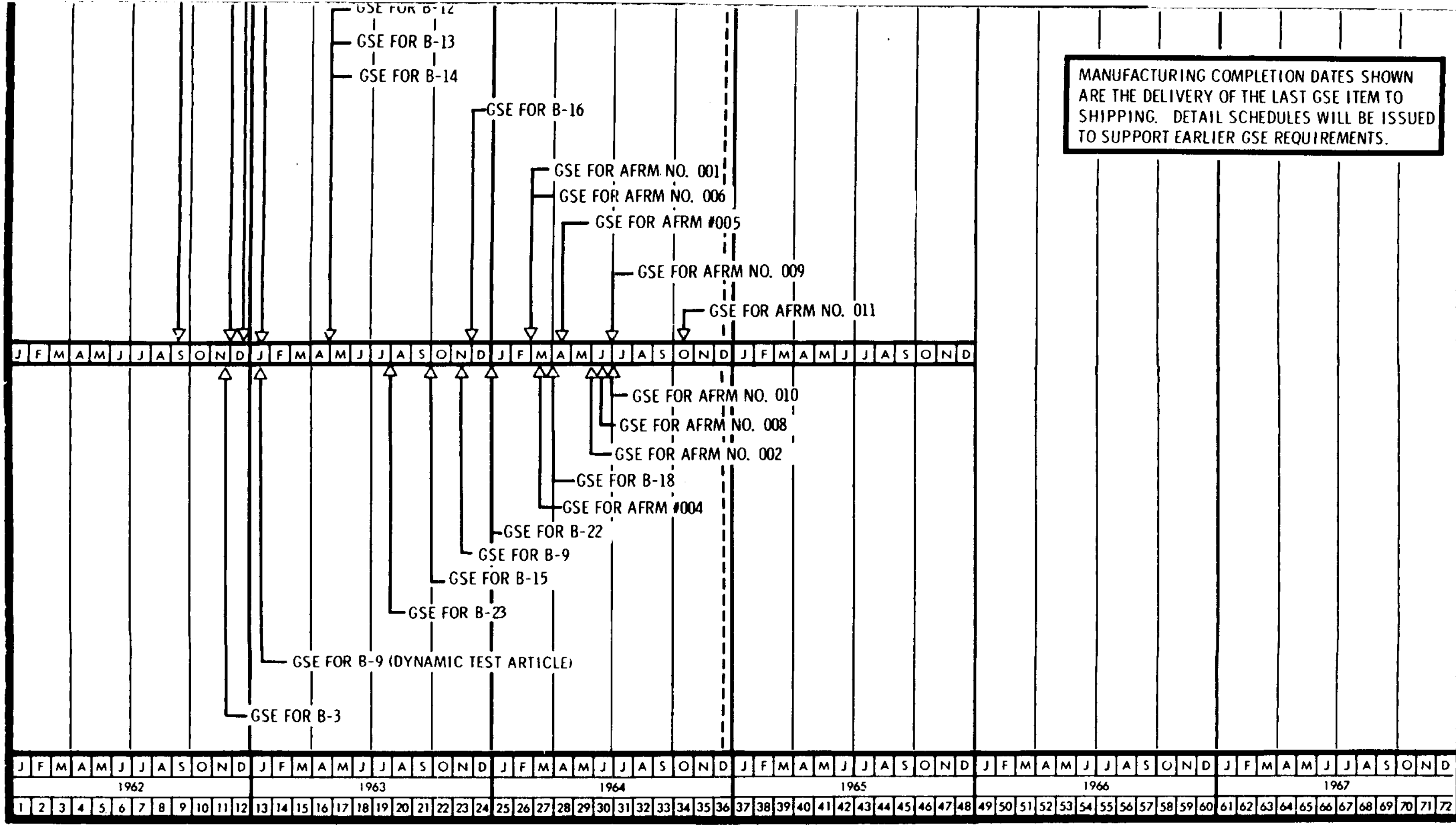




1ST S/C C/M MFG COMPLETE
100% S/C DESIGN RELEASE, INSTRUMENTATION - S/M
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
100% DES. REL. GSE
FINAL S/C DESIGN RELEASE, INSTRUMENTATION - C/M
FINAL S/C DESIGN RELEASE, NAVIGATION & GUID INSTL - C/M
100% DES REL PART TASK TRAINERS
100% S/C DESIGN RELEASE, MAJ SUB-SYST INSTL - C/M
100% S/C DESIGN RELEASE, MAJOR SUB-SYST INSTL - S/M
100% DES REL B - 9 DYNAMIC TEST ARTICLE
65% S/C DESIGN RELEASE, STRUCTURE - C/M
MAJOR HARDWARE COMPLETIONS
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
TRAINER MANUFACTURING COMPLETIONS
ORBITAL & RENDEZVOUS (PART TASK TRNR)
NAVIGATION & TRAJECTORY CONT (PART TAST TRNR)
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
MISSION SIMULATOR NO. 2 (COMPL)
MISSION SIMULATOR NO. 1 (COMPL)
EARTH LAUNCH & RE-ENTRY (PART TASK TRNR)
MILESTONE
MILESTONE COMPLETE
MILESTONE RESCHEDULED



MANUFACTURING COMPLETIONS
MOCK-UPS—ENGINEERING SIMULATORS
M-7-COMPLETE SERVICE MODULE
M-12-CREW SUPPORT SYSTEM
M-9-S/C HANDLING & TRANSPORTATION
SIMULATOR S-1
SIMULATOR S-2
M-18-COMPLETE MOCK-UP
M-2-CABIN INTERIOR ARRANGEMENT
M-11-S/C HANDLING & TRANSPORTATION
M-5-CABIN EXTERIOR EQUIPMENT
M-4 S/M & ADAPTER INTERFACE
M-3-CABIN INTERIOR ARRANGEMENT
GSE MANUFACTURING COMPLETIONS
GSE FOR B-1
GSE FOR B-2
GSE FOR B-19
GSE FOR B-6



Apollo Master Development Schedule (Sheet 1 of 2)

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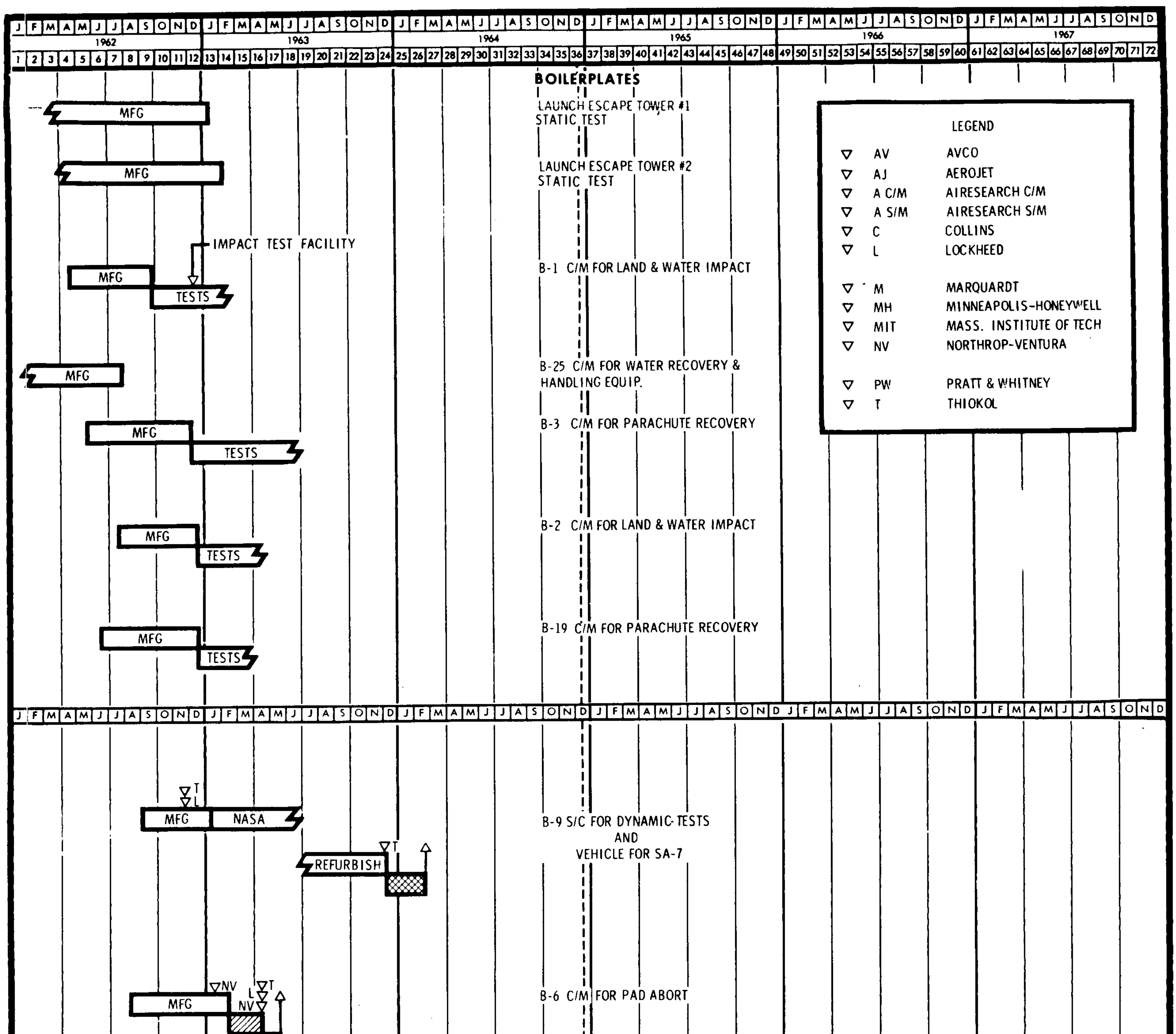

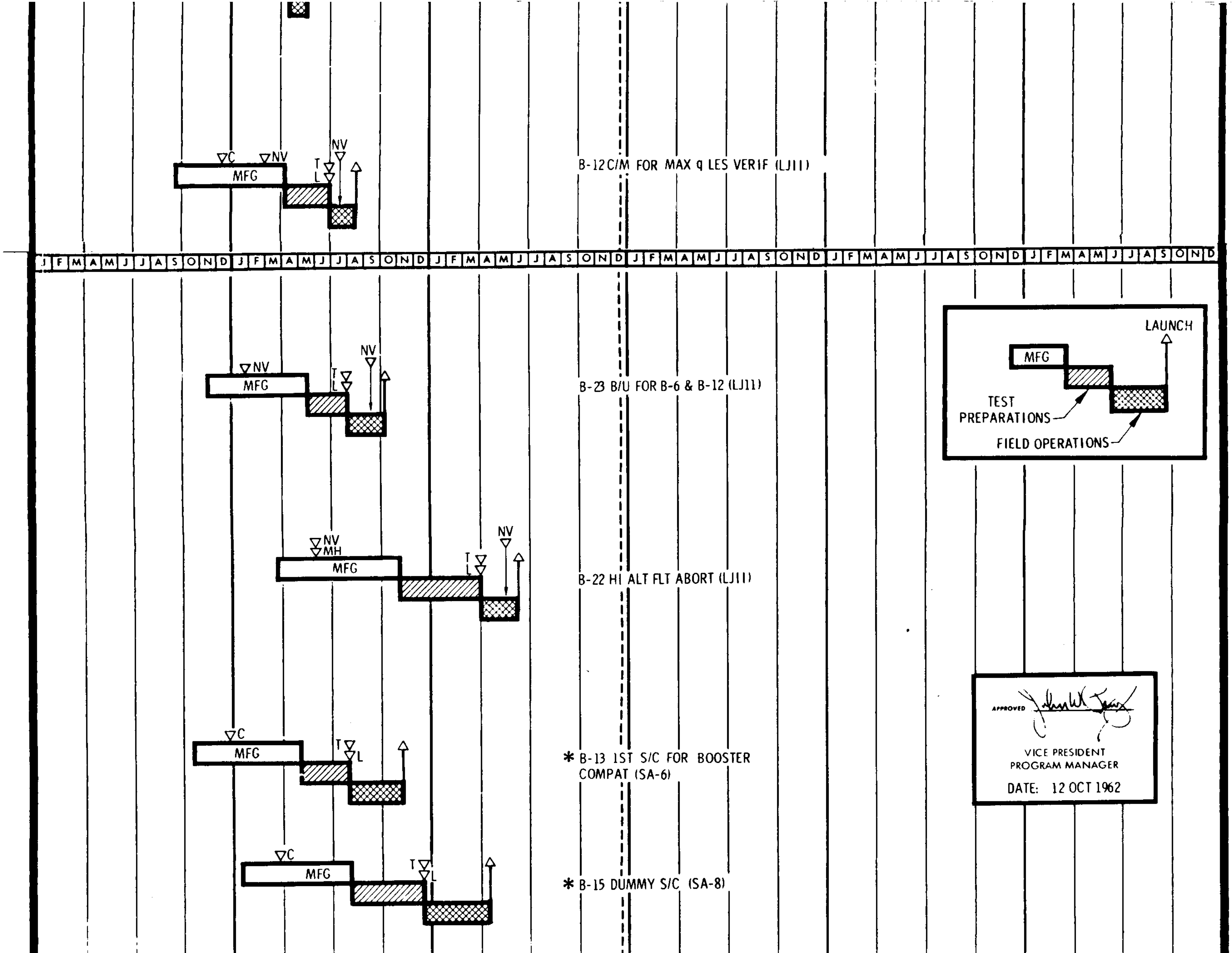

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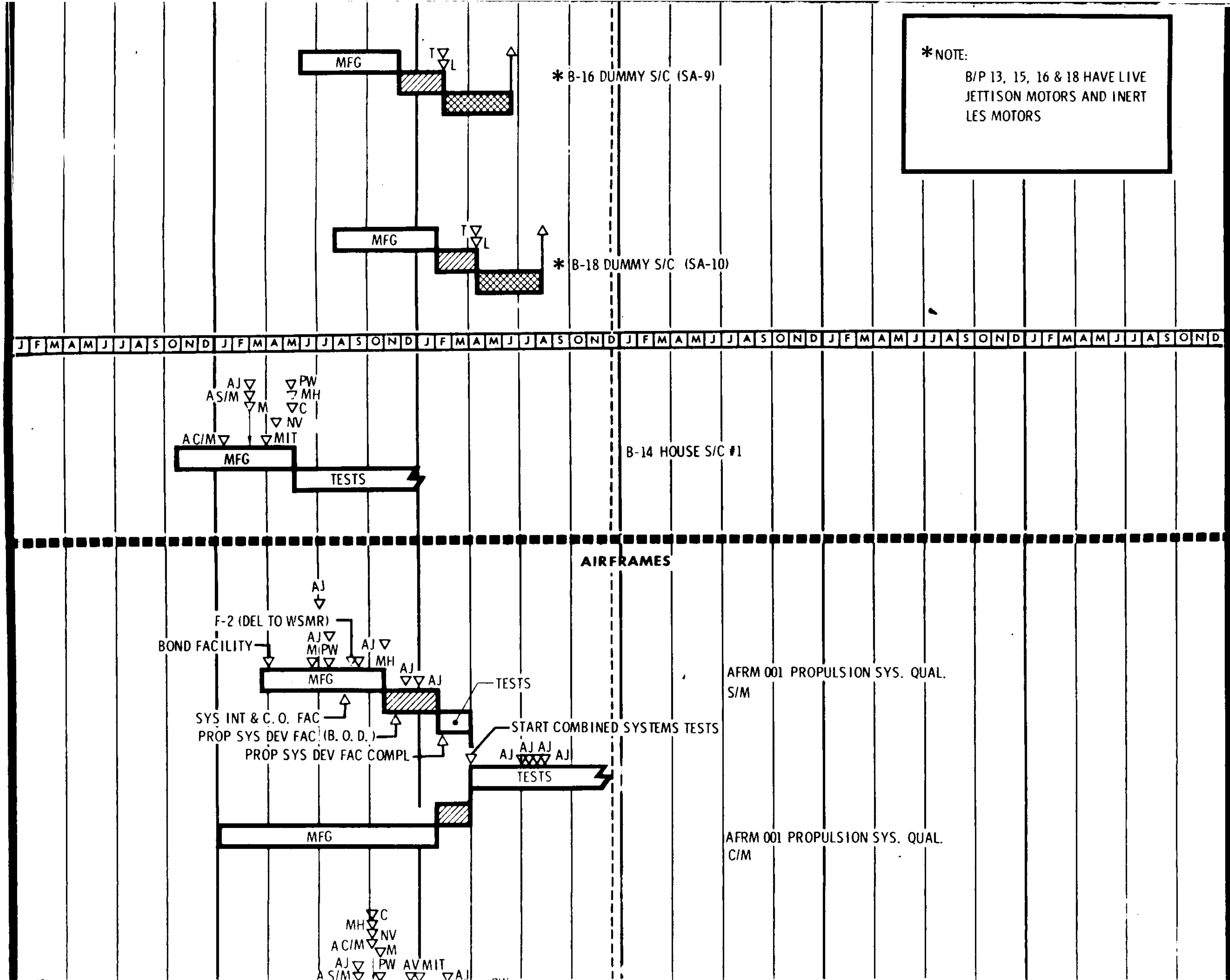
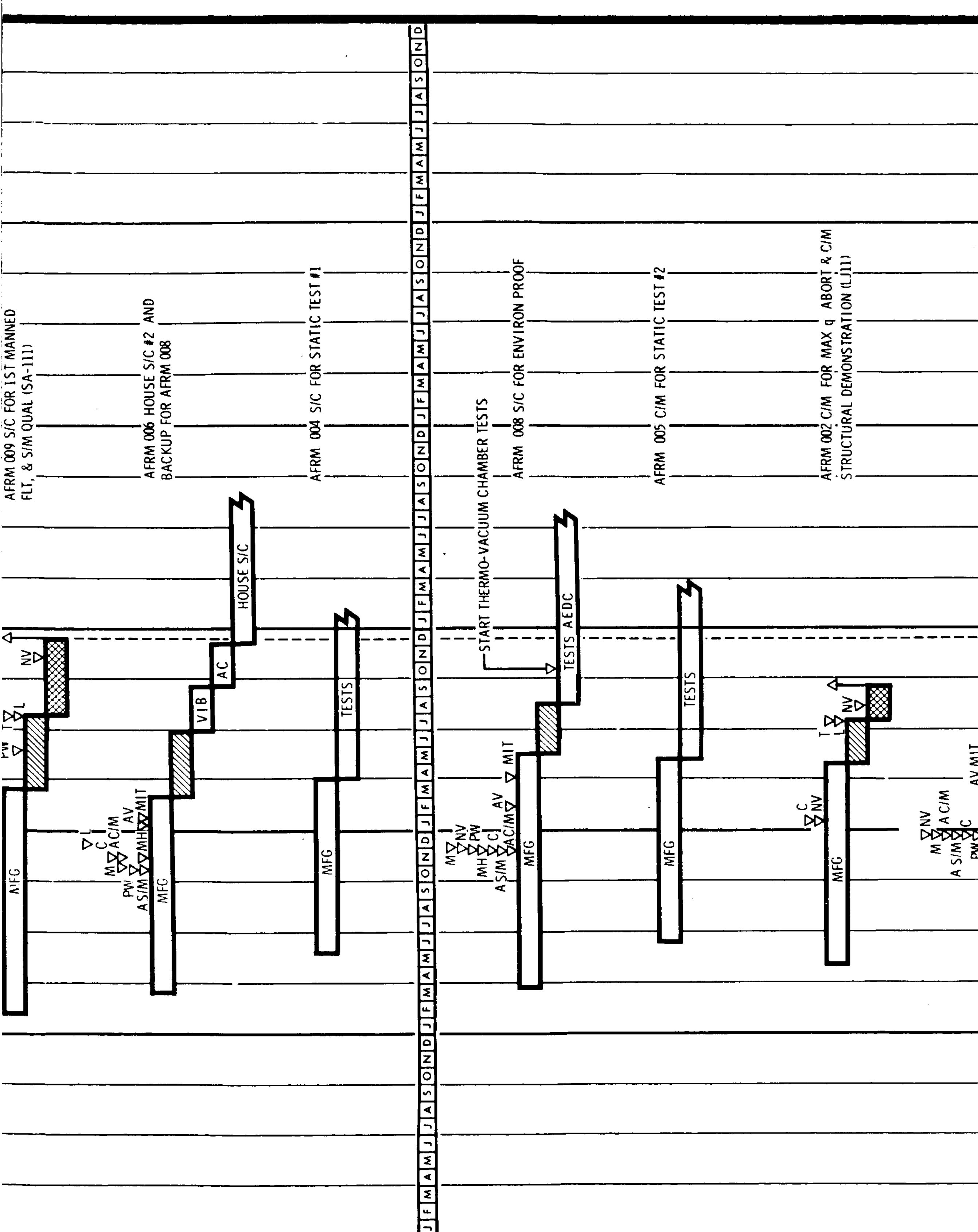
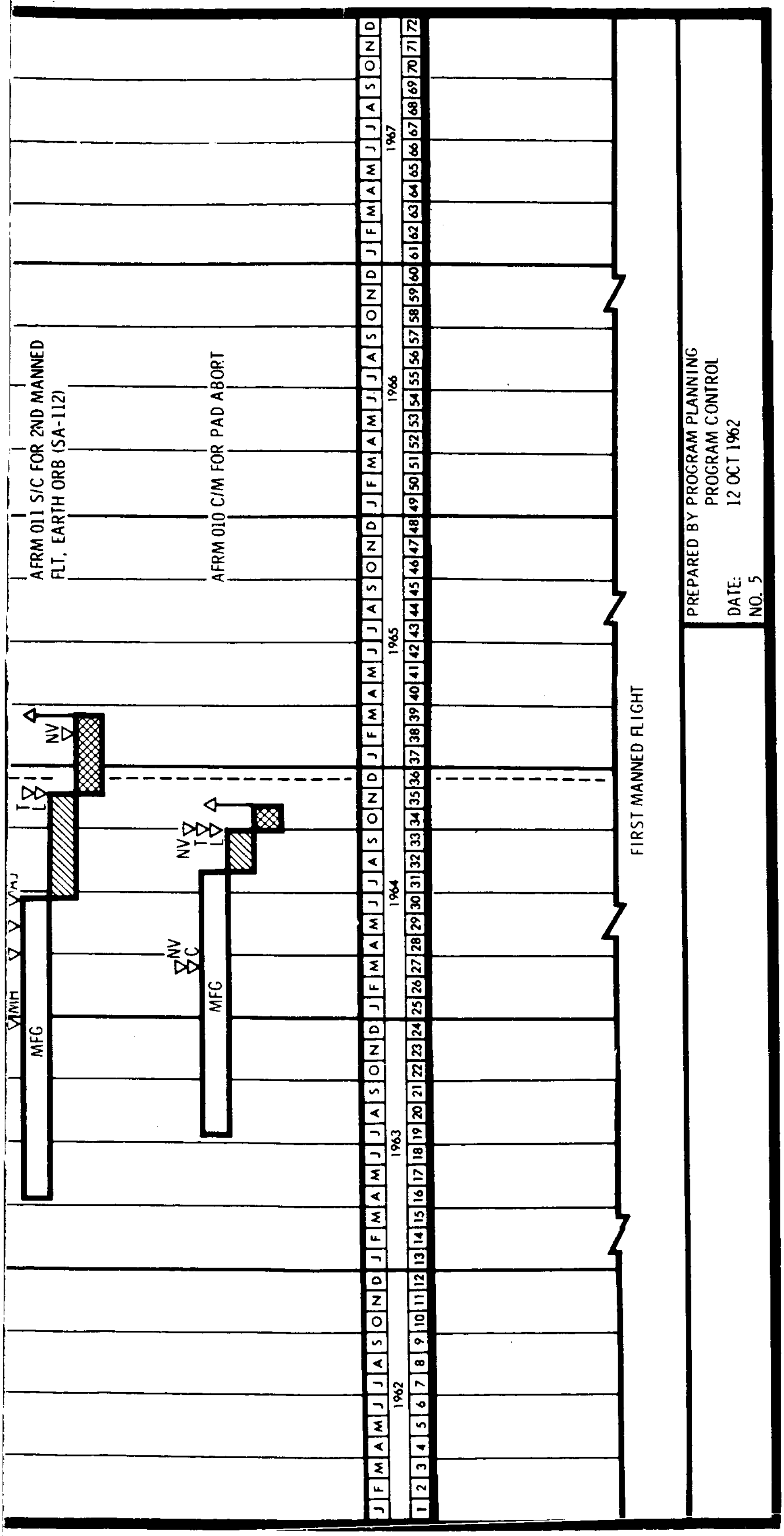
B-12 C/M FOR MAX q LES VERIF (LJ11)
B-23 B/U FOR B-6 & B-12 (LJ11)
B-22 HI ALT FLT ABORT (LJ11)
* B-13 1ST S/C FOR BOOSTER COMPAT (SA-6)
* B-15 DUMMY S/C (SA-8)
MFG
C
NV
MH
T
L
LAUNCH
TEST PREPARATIONS
FIELD OPERATIONS
APPROVED
VICE PRESIDENT
PROGRAM MANAGER
DATE: 12 OCT 1962



*NOTE:
B/P 13, 15, 16 & 18 HAVE LIVE JETTISON MOTORS AND INERT LES MOTORS
MFG
T
L
* B-16 DUMMY S/C (SA-9)
MFG
T
L
* B-18 DUMMY S/C (SA-10)
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
AJ
AS/M
M
PW
MH
C
NV
MIT
AC/M
MFG
TESTS
B-14 HOUSE S/C #1
AIRFRAMES
AJ
F-2 (DEL TO WSMR)
BOND FACILITY
AJ
M PW
AJ
MH
AJ
AJ
MFG
TESTS
SYS INT & C. O. FAC
PROP SYS DEV FAC (B. O. D.)
PROP SYS DEV FAC COMPL
START COMBINED SYSTEMS TESTS
AJ
AJ AJ
AJ
TESTS
AFRM 001 PROPULSION SYS. QUAL. S/M
MFG
AFRM 001 PROPULSION SYS. QUAL. C/M
C
MH
NV
AC/M
M
AJ
PW
AV MIT
AS/M
AJ


AFRM 009 S/C FOR 1ST MANNED FLT, & S/M QUAL (SA-111)
AFRM 006 HOUSE S/C #2 AND BACKUP FOR AFRM 008
AFRM 004 S/C FOR STATIC TEST #1
START THERMO-VACUUM CHAMBER TESTS
AFRM 008 S/C FOR ENVIRON PROOF
AFRM 005 C/M FOR STATIC TEST #2
AFRM 002 C/M FOR MAX q ABORT & C/M STRUCTURAL DEMONSTRATION (LJ11)
MFG
HOUSE S/C
VIB
AC
TESTS
TESTS AEDC
MIT
NV
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D



Apollo Master Development Schedule (Sheet 2 of 2)

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